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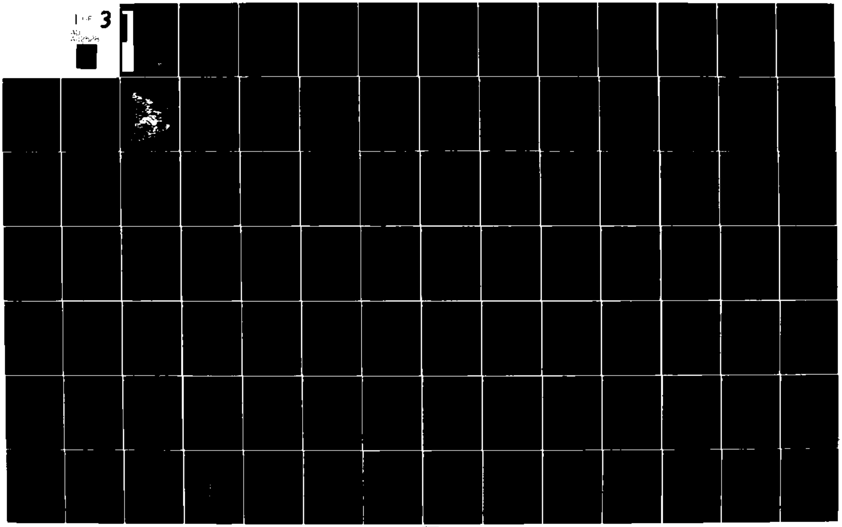

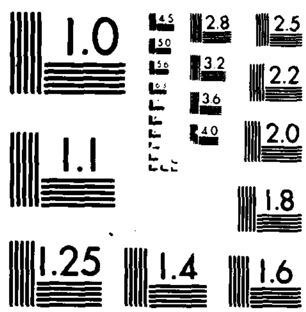

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

MX SITING INVESTIGATION

WATER RESOURCES PROGRAM
INTERIM REPORT, FY 80

PREPARED FOR
BALLISTIC MISSILE OFFICE (BMO)
NORTON AIR FORCE BASE, CALIFORNIA

FUGRO NATIONAL, INC.
Consulting Engineers and Geologists

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Results of [illegible] reconnaissance field investigations conducted in eight valleys in Nevada and Utah [illegible] that surface water [illegible] appropriated and that ground water is the most likely source for MX construction. Ground water [illegible] in one valley exceeds perennial yield, perennial yield [illegible] in two valleys if MX [illegible] into existence, and ground water [illegible] in five valleys would not [illegible] MX [illegible]

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MX SITING INVESTIGATION
WATER RESOURCES PROGRAM
INTERIM REPORT

Prepared for:

U.S. Department of the Air Force
Ballistic Missile Office (BMO)
Norton Air Force Base, California 92409

Prepared by:

Fugro National, Inc.
3777 Long Beach Boulevard
Long Beach, California 90807

31 October 1980

FOREWORD

This report was prepared for the Department of the Air Force, Ballistic Missile Office (BMO), in compliance with Contract Number F04704-80-C-0006, CDRL Item 004A2. It presents water resources evaluations of eight valleys in the Nevada-Utah siting area based on field work that was completed between 1 April and 30 June 1980 and an update of the status of all water resources programs through Fiscal Year 1980 (FY 80). This information is submitted at this time so that it can be incorporated into the Final Environmental Impact Statement.

The Water Resources Program is a continuing investigation which was started in June 1979 and will continue through FY 81. Many of the water resource investigative activities are still in progress, and more comprehensive evaluations will be possible when these tasks are completed.

The report consists of two main sections:

- Text section providing evaluations of valley ground water in the siting area; assessment of the potential impacts of MX ground-water withdrawals on the local water users, the environment, and the aquifers; and the measures that could be employed to mitigate the impacts; and

- Appendices containing basic hydrogeologic data collected by Fugro National, Inc. from field hydrologic reconnaissance and drilling and testing programs and from existing data sources.

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EXECUTIVE SUMMARY

Introduction

This report is the third summary report of the MX Water Resources Program that was initiated in June 1979. Previous Water Resources Program summary reports were presented to the BMO on 21 December 1979 and 15 May 1980. These reports collectively presented the results of the hydrologic investigations conducted between 1 July 1979 and 1 April 1980 of 16 valleys in the siting area. This report included the results of field investigations conducted between 1 April and 30 June 1980 in eight valleys within the siting area (Big Sand Springs, Coal, Garden, Lake, Muleshoe, Pahroc, Penoyer, and Spring). Also included are a summary of the results and conclusions of Phase II of the Water Rights Legal Study, the Industry Activity Inventory, and a summary of the status of all ongoing subprograms.

Pursuant to the investigation of these eight valleys, field activities have included one aquifer (pump) test; collection of 35 water samples for quality analyses; 76 ground-water level measurements; and 45 spring, stream, and flowing-well discharge measurements. Field hydrologic reconnaissances have also been completed in an additional five valleys. Only one aquifer test of existing wells was made because of availability of suitable wells or owner cooperation. In addition, 14 valley-fill test and observation wells have been drilled in 12 valleys (two wells are in progress), one carbonate test well has been completed, and two are in progress for the period 1 April to 1 October 1980.

The results of the drilling and the aquifer tests in these wells have not yet been analyzed. The results of the recent field investigations will be presented in a progress report scheduled for submission in January 1981.

Results and Conclusions

Surface water in the valleys included in this report is quite limited, except for Spring Valley, and is considered to be almost entirely appropriated and utilized. Ground water from valley-fill aquifers is the most likely source of water for MX construction and is believed to be physically obtainable in all eight valleys. Based on perennial-yield and current-ground-water-withdrawal estimates, ground-water development currently exceeds the perennial yield in Penoyer Valley. In the event that additional water could not be appropriated in Penoyer Valley, water rights could be leased or purchased or water imported from Railroad Valley to the northwest for construction supplies. Additionally, if MX water requirements were added to current ground-water withdrawal rates, the perennial yield would be exceeded in Big Sand Springs and Lake valleys. Because of the large quantity of water in storage in Big Sand Springs Valley and the minimal current water use, MX withdrawals are not expected to cause detrimental effects. In Lake Valley, water rights may have to be leased or purchased, water imported from Spring Valley, or possible carbonate aquifers developed. No perennial-yield estimates have been made by the state specifically for Muleshoe and Pahroc valleys; they are part of larger hydrographic basins. MX water requirements in Muleshoe and Pahroc valleys are relatively small with 1079 acre-feet per year (acre-ft/yr) (1.33 cubic hectometers per year [hm^3/yr]) and 807 acre-ft/yr (1.00 hm^3/yr), respectively, and are not expected to impact the few water users nor the environment.

MX requirements will probably not exceed ground-water availability in Coal, Garden, and Spring valleys. Fugro National will prepare a water management plan which will identify the optimum water supply alternatives for each of these valleys. This information will be presented in the water management report to be submitted in September 1981.

Water quality was evaluated for the eight valleys studied according to criteria for drinking water listed in Table C1-1. Except for a few localized areas (shown in Drawings D1-1 through D1-8) which contain water of poor quality, all of the water analyzed from these valleys was of good quality. Generally, water classified as being of poor quality was high (greater than 500 milligrams per liter [mg/l]) in Total Dissolved Soils (TDS) and had high concentrations of calcium and magnesium which are usually associated with water discharging from or flowing through carbonate rock terrain. All of the water sampled was potable.

Results of the Industry Activity Inventory of the entire siting area indicate that current ground-water withdrawal exceeds the estimated perennial yield in three valleys: Big Smoky, Penoyer, and the Sevier Desert. In these valleys, the state engineers in both Nevada and Utah may not accept applications for additional ground-water withdrawal. If additional appropriations are not allowed, the water required to meet MX construction needs in these valleys would have to be purchased or leased from current users or would have to be imported from a neighboring valley where water is more plentiful.

Ground-water rights certificates and proofs presently exceed the perennial yield in three valleys in the siting area: Penoyer, Stone Cabin, and the Sevier Desert. However, as indicated by the Water Rights and Industry Activity inventories, about 93 percent of the amount of certificates and proofs are currently being utilized. Additionally, ground-water rights in all stages of application and appropriation exceed the perennial yield in most of the valleys in the siting area. However, approximately one-half of these applications were filed in the last four or five years under the Carey and Desert Land Entry Acts and may not be acted upon by the state engineer pending release of the lands from the public domain. Generally, a very small percentage of these applications ever become valid water rights.

1.0 INTRODUCTION

1.1 BACKGROUND

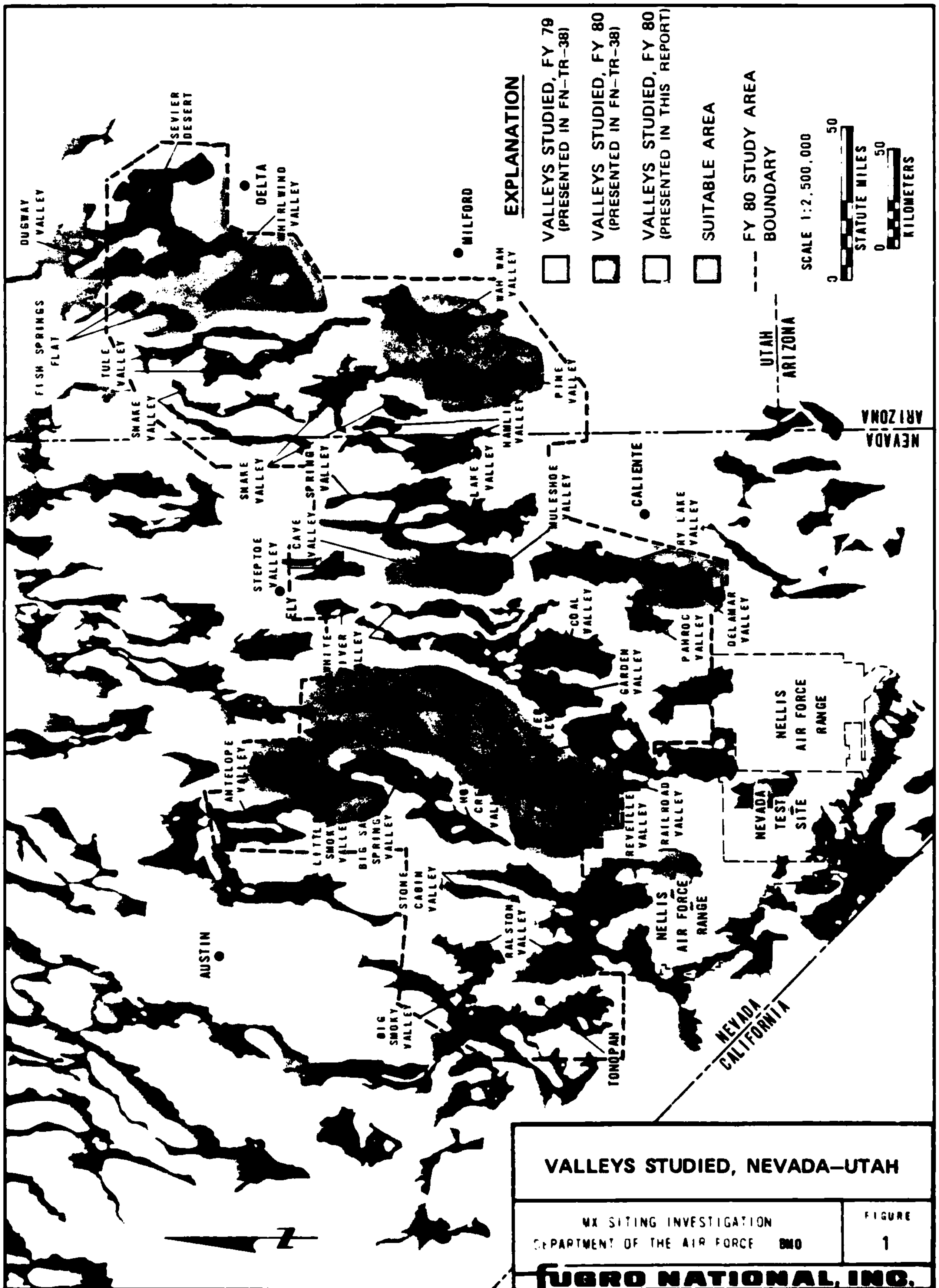
The potential MX siting area lies within the arid to semiarid Great Basin region of Nevada-Utah. As a result of low precipitation and high evapotranspiration rates, surface water and shallow ground water are relatively scarce in this area. Most of the readily obtainable water supplies of acceptable quality are limited in areal extent, generally confined to portions of certain hydrographic valleys, and are presently under development for urban, industrial, or agricultural purposes. Additionally, throughout most of the siting area, the relatively small quantity and seasonal nature of surface-water runoff and the generally great depth at which the ground water lies (commonly over several hundred feet) have largely precluded the development of water resources except for minor amounts for stock watering. In this large area, few data are available concerning the occurrence, quantity, and quality of ground water.

The MX Water Resources Program was initiated in June 1979 for the purpose of evaluating the availability of water for both the construction and operational phases of the MX project in Nevada and Utah. The first preliminary findings report, "MX Siting Investigation, Geotechnical Summary, Water Resources Program FY 79 (Fiscal Year 1979)," was submitted to the Ballistic Missile Office (BMO) on 21 December 1979. Included were a summary of the general hydrologic conditions in the siting area, the results of FY 79 field reconnaissance studies conducted by Fugro National in Big Smoky, Dry Lake, Hamlin, Snake, Tule, and White River valleys (Figure 1) and a summary of the results of Phase I of the legal study, "Overview of Nevada and Utah Water Law: Historical Development and Current Procedures for Rights Acquisition." The revised Phase I legal study was executed by the Desert Research Institute (DRI), University of Nevada System, and was submitted in its entirety to the BMO on 2 June 1980.

The second summary report, "MX Siting Investigation, Water Resources Program, Summary for Draft Environmental Impact Statement," was submitted concurrently to the BMO and Henningson, Durham and Richardson (HDR) Sciences in Santa Barbara, California, on 15 May 1980. The report was submitted to HDR Sciences at that time so that applicable water resource information could be incorporated into the Draft Environmental Impact Statement for the MX project. The Fugro National summary report included all preliminary findings of the Water Resources Program conducted to 1 April 1980 and consisted of three volumes which included the following:

Volume I - Main text providing evaluations of 16 valleys; Big Smoky, Cave, Dry Lake, Delamar, Dugway, Fish Springs Flat, Little Smoky, Pine, Railroad, Sevier Desert, Snake, Hamlin, Tule, Wah Wah, Whirlwind, and White River and which includes the six valleys studied in FY 79 (Figure 1); a general summary of the regional ground-water resources in the siting area; assessment of the potential impacts of MX ground-water withdrawals on the local water users, the environment, and the aquifers; and the measures that could be employed to mitigate the impacts;

Volume II - Data volume consisting of basic hydrogeologic data collected by Fugro National, Inc. from field hydrologic reconnaissance, drilling, and testing programs and from existing data sources; and



VALLEYS STUDIED, NEVADA–UTAH

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE BMO

FIGURE 1

FUGRO NATIONAL, INC.

Volume III - Municipal water-supply and wastewater-treatment facilities reports for the potentially effected communities in or near the MX siting area in Nevada and Utah. The studies were conducted for Fugro National by DRI for Nevada, and by Utah Water Research Laboratory (UWRL); Logan, Utah, for the Utah portion of the MX siting area. Both reports were also submitted under separate cover, together with a summary, to the BMO on 20 June 1980.

This is the third preliminary findings report of the MX Water Resources Program presenting the field studies that were completed between 1 April and 30 June 1980, a brief description of ongoing water resources investigations, a summary of the approach and scope of the current program, the hydrological evaluation of eight valleys: Big Sand Springs, Coal, Garden, Lake, Muleshoe, Pahroc, Penoyer, and Spring, and the location of the valleys studied (Figure 1). Summaries of the results and conclusions of the Water Rights Inventory and the Industry Activity Inventory are also included within this report. Phase II of the legal study, "Water Rights in Nevada and Utah: An Inventory Within the MX Area," was conducted by DRI. The Industry Activity Inventory consisted of two separate reports conducted by DRI and UWRL for Nevada and Utah, respectively. The Industry Activity Inventory was submitted to the BMO under separate cover in September 1980. The final water rights inventory was submitted to the BMO 19 December 1980. Explanation of the terms used in the hydrologic discussions is provided in Appendix H1.0, Glossary of Selected Hydrogeologic Terminology. A MX Water Resources Program progress report will be submitted in January 1981, and the final MX Water Resources Program technical summary report is currently scheduled to be submitted in July 1981.

1.2 APPROACH AND SCOPE

The general approach of the MX Water Resources Program is to update and expand the existing data base in the Nevada-Utah siting area in order to identify and quantify aquifer characteristics, ground-water and surface-water regimes, water quality, and water use and appropriations in the region. A program of aquifer testing, determination of local and regional ground-water flow patterns, analysis of water quality characteristics, and computer simulations of the effects of pumping on water levels in wells and springs is being conducted. This information will provide the basis for evaluating the likely effects, if any, of MX ground-water withdrawals on local water users and on the environment and will provide information in support of water appropriation applications. It will also aid in design of well fields for construction water supply and operations facilities. This information is being obtained through the following activities and studies:

- Review existing pertinent publications and data contained in agency files relating to water availability, local water use, regional ground-water flow systems, and aquifer characteristics.
- Contact various state and federal officials knowledgeable about ground-water conditions in Nevada and Utah.
- Perform hydrogeologic field studies to identify water users, measure ground-water levels, collect ground-water samples for chemical analyses, measure spring and stream discharges, conduct aquifer tests of existing wells, and overview general hydrogeologic conditions:
  - Measure ground-water levels in selected wells and drill holes in order to construct potentiometric maps for identifying ground-water migration patterns and areas of recharge or discharge and as an aid in calculating expected pumping lifts for well design;

- Collect ground-water samples from wells and springs to characterize the water quality and assess its suitability for construction or drinking purposes and as an aid in identifying ground-water migration patterns and recharge areas;

- Measure spring and stream discharges to aid in surface water studies and to provide input to computer model simulations of the ground-water systems in the area; and

- Conduct aquifer tests in selected existing wells to determine potential well yields and the aquifer's ability to store and transmit water (this information is needed in designing well fields and in evaluation of the optimum yield).

o Drill and test shallow depth, valley-fill aquifers (about 500 feet [152 m]), intermediate-depth, valley-fill aquifers (about 1000 feet [305 m]) and carbonate aquifers. The drilling and testing programs are designed to gather information about aquifer characteristics and regional ground-water flow systems where little data exist. In addition, tests are being conducted to determine the effects of pumping on nearby wells and springs to provide information in support of water appropriation applications.

o Evaluate regional and basin structures to better understand regional ground-water flow systems (use of this information is described in Appendix G1.4).

o Make computer numerical models of the ground-water system in selected valleys. This will aid in assessing the effects of MX ground-water withdrawals on the local water users and the environment. The current status of this program is listed in Appendix G1.5.

o Investigate surface-water regime to provide data on the availability of surface water and the rates and amounts of potential recharge to the ground-water systems. The results will be input to the valley computer models to enhance the accuracy of the modeling results.

o Assess the relationship between evapotranspiration and depth to ground water in selected valleys to determine the amount of water consumed by phreatophytes and to use as an input parameter to the computer models.

o Assess municipal water-supply and waste-water treatment facilities for their capacity to handle increased demand and loads due to MX population influx. This study includes towns within and immediately adjacent to the siting area with emphasis on Tonopah, Ely, Caliente, and Pioche in Nevada and

Delta, Milford, and Cedar City in Utah. This study was conducted by the Desert Research Institute for Nevada and the Utah Water Research Laboratory for Utah.

- Review and study Nevada and Utah water laws and permitting procedures and conduct a water-rights inventory. This study has been conducted by the Desert Research Institute for both states and has aided in the filing of water appropriation applications. A summary of the results and conclusions of the second phase of this study is presented in Section 4.0.

- Compile an industry activity inventory to identify the water requirements of existing and proposed industries in the siting area and determine how these requirements may interact with MX construction and operational activities. This study was conducted by the Desert Research Institute for Nevada and the Utah Water Research Laboratory for Utah. A summary of the results of this study is presented in Section 5.0.

- Assess the quantity of water required by MX activities in each valley and submit an application for appropriation. Define points of diversion for ground-water withdrawal and survey diversion sites. The status of this program is presented in Appendix G1.9.

The scope of field activities in the eight study valleys is listed in Table 1. Most of the field activities discussed above have been conducted in these areas.

VALLEY	ACTIVITY			
	AQUIFER TEST	WATER QUALITY ANALYSIS	WATER LEVEL MEASUREMENT	DISCHARGE MEASUREMENT
BIG SAND SPRINGS	0	1	3	4
COAL	0	1	6	1
GARDEN	0	10	18	9
LAKE	0	0	7	0
MULESHOE	0	3	1	8
PAHROC	0	1	5	1
PENOYER	1	5	7	8
SPRING	1	14	29	14

FUGRO NATIONAL FIELD ACTIVITIES
NEVADA - UTAH

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE – BMO

TABLE 1

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2.0 REGIONAL WATER RESOURCES

2.1 PRESENT DEVELOPMENT

Due to the economics of ground-water extraction, most development within the general siting area is limited to shallow aquifers (i.e., aquifers at depths of 500 feet [152 m] or less). Accordingly, the shallower valley-fill aquifers have a much greater data base than that for the intermediate depth (500 to over 1000 feet [152 to 305 m]) valley-fill aquifers or the carbonate aquifers. The development of ground water is quite variable from valley to valley. In a few agricultural areas such as Steptoe, White River, Snake, Tule, and Hamlin valleys and the Sevier Desert, there is appreciable development of ground-water supplies with, in some cases, lengthy histories of pumping withdrawals. Other areas, notably Cave, Pine, Big Sand Springs, Coyote Spring, Kane Springs, Dry Lake, Delamar, Garden, and Coal valleys, have very sparse ground-water development.

Very little information is available for the intermediate-depth, valley-fill aquifers. A number of valleys within the siting area have average depths to ground water in excess of 350 feet (107 m). These valleys are Dry Lake, Delamar, Pahroc, Kane Springs, Coal, Garden, and Coyote Spring valleys in Nevada and Pine, Wah Wah, and the eastern portions of Whirlwind valleys in Utah. In these valleys, current withdrawals and proposed MX ground-water development are largely limited to the intermediate-depth, valley-fill aquifers. Because of the expense of deep wells, there is very little development in valleys where the depth to water is great.

Outside of the Nevada Test Site, little is known about the potential of the carbonates for ground-water development. The deep carbonate aquifer is a potential alternative source of ground-water for valleys with limited ground-water supplies in the valley-fill aquifers.

2.2 WATER AVAILABILITY

In areas of Nevada where allocations of ground water approach or surpass the perennial yield, the valleys have been "designated" as critical ground-water basins. Valleys within the siting area which are so designated are Big Smoky, Lake, Penoyer, Stone Cabin, Ralston, Steptoe, and most recently, Reveille. Further ground-water development in designated valleys is at the discretion of the Nevada State Engineer. Likewise, overdraft in irrigated areas of the Sevier Desert resulted in the closing of this ground-water basin to additional development except at the discretion of the Utah State Engineer.

Listed in Table 2 is the estimated quantity of water available annually in each siting valley. It is assumed that the water available could be used for MX. Water availability is defined as the perennial yield less current usage and does not take into consideration pending applications for appropriation or appropriated water supplies which are not currently being utilized. The future water resources growth potential within the siting area was also not considered in this table. The state engineer in the respective states will consider these factors along with the relatively short construction schedule

VALLEY	PERENNIAL YIELD (Acre-Ft/Yr)	CURRENT ANNUAL GROUND-WATER USE (Acre-Ft/Yr)	ESTIMATED ANNUAL GROUND-WATER AVAILABILITY (Acre-Ft/Yr)
NEVADA			
ANTELOPE(1)	>4,000	437	>3,563
BIG SAND SPRINGS	1,000	0	1,000
BIG SMOKY(2)	9,000	33,927	−24,927
BUTTE	14,000	unknown	unknown
CAVE	2,000	0	2,000
COAL	6,000	0	6,000
DELAMAR	3,000	7	2,993
DRY LAKE(3)	3,000	0	3,000
GARDEN	6,000	91	5,909
HAMLIN	5,000	852	4,148
HOT CREEK	6,000	297	5,703
JAKES	12,000	unknown	unknown
KOBEH	16,000	unknown	unknown
LAKE(4)	17,000	14,166	2,834
LITTLE SMOKY	> 5,000	0	>5,000
LONG	6,000	unknown	unknown
MONITOR	18,000	338	17,662
NEWARK	18,000	6,507	11,493
PAHROC	unknown	minor	unknown
PENOYER	5,000	5,691	−691
RAILROAD	75,000	4,206	70,794
RALSTON	6,000	1,005	4,995
REVEILLE	unknown	minor	unknown
SNAKE	69,000	15,756	53,244
SPRING	100,000	4,781	95,219
STONE CABIN	2,000	970	1,030
WHITE RIVER	37,000	5,262	31,738
UTAH			
DUGWAY	< 12,000	3,286	< 8,714
FISH SPRINGS FLAT	35,000	393	34,607
PINE	7,000	78	6,982
SEVIER(5)	24,500	49,261	−24,761
TULE	32,000	20	31,980
WAH WAH	< 10,000	2	<9,998

MINOR = less than 100 acre-ft/yr (0.1 hm^3/yr).

Current ground—water use estimates are from the DRI and UWRL Industry Activities Inventories.

Perennial yield estimates are from various state and federal agencies except for the Sevier Desert which was calculated by Fugro National based on published data.

Negative ground-water availability numbers indicate overdraft conditions.

Zero current annual ground-water use numbers indicate withdrawal is very minor; however, a small amount of ground-water use may occur in these valleys.

NOTES:
1. Includes Steven's Basin.
2. Includes Alkali Spring Flat.
3. Includes Muleshoe Valley (Dry Lake / Muleshoe).
4. Includes Patterson Valley.
5. Includes Dry Lake Subarea (Sevier / Whirlwind).

ESTIMATED GROUND-WATER AVAILABILITIES
NEVADA—UTAH

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE — BMO

TABLE 2

FUGRO NATIONAL, INC.

and associated water requirement time (less than two years at peak requirement) in each siting valley before granting water appropriation rights for MX.

Perennial yield was used to estimate water availability because it is recognized that the surface-water resources in the siting area are, at present, nearly or totally utilized. Water requirements for the MX project will have to be supplied by ground-water resources except where surface-water rights are leased or purchased.

Based on the estimated construction-water requirements of the MX project, current ground-water withdrawal, and on the estimated perennial yield, it appears that ground-water withdrawals may exceed the perennial yield in only a few valleys in the siting area. These valleys are Big Sand Springs, Big Smoky, Dry Lake, Penoyer, Sevier Desert, and Stone Cabin. It is believed, however, that ground water is physically obtainable in all the valleys in the siting area, and that ground-water withdrawal from aquifers in these valleys would be replenished through normal hydrologic processes following construction. In several valleys in Nevada, the water may not be made available through new appropriations because the valleys are designated. In these valleys, however, it may be possible to purchase or lease existing surface and/or ground-water rights, or import water from a neighboring valley where water is more plentiful, for the approximate two- to three-year estimated construction period.

2.3 MX WATER REQUIREMENTS

MX water requirements have been divided into the construction and operational phases of the project. The construction phase includes cluster construction, associated road network construction, and Operational Base construction. Cluster construction is scheduled to begin in 1984 and continue through 1989. Operational Base construction is currently scheduled to begin in 1982 and be completed by 1986. The most probable peak-construction water-requirement for a two-base system with the primary Operational Base in Coyote/Springs Valley is currently estimated to be 5200 acre-ft/yr (6.4 hm^3/yr) (Henningson, Durham and Richardson, 1980). Construction of the Designated Transportation Network (DTN) is scheduled to begin in 1982. Under current scheduling, about 280 miles (451 km) of DTN are estimated to be constructed in about 11 valleys during 1982 and 1983. DTN construction is estimated to require about 7.5 acre-feet (0.009 hm^3) of water per mile. Thus, about 2100 acre-feet (2.6 hm^3) of water will be required. This requirement was previously calculated into the peak year requirements as shown in Table 3. Any water use for DTN construction prior to the cluster-construction period will reduce the estimated peak cluster-construction requirement by an equivalent amount.

Table 3 shows the projected maximum and probable MX water requirements for construction in each of the Nevada and Utah siting valleys and the anticipated year(s) of construction. Although the ccnstruction of road networks is scheduled to begin in 1982, water requirements for the first two years are

VALLEY	CONSTRUCTION PERIOD (month-year)	ESTIMATED PROBABLE REQUIREMENT (Acre-Ft/Yr)	ESTIMATED MAXIMUM REQUIREMENT (Acre-Ft/Yr)
NEVADA			
ANTELOPE (1)	7-88 through 10-89	2439	3805
BIG SAND SPRINGS	7-86 through 1-88	1351	2076
BIG SMOKY (2)	7-87 through 2-89	3255	4146
BUTTE	Not available	1895	2464
CAVE	7-85 through 1-87	1351	2076
COAL	7-85 through 5-87	2167	3456
DELAMAR	11-84 through 8-86	1351	1585
DRY LAKE / MULESHOE	11-84 through 8-86	3255 / 1079	3810 / 1731
GARDEN	7-85 through 5-87	2167	3456
HAMLIN (3)	7-85 through 4-88	3255	3464
HOT CREEK (4)	7-86 through 1-88	1895	3115
JAKES	Not available	1097	1758
KOBEH	Not available	2167	3530
LAKE (5)	6-85 through 8-86	2439	3805
LITTLE SMOKY	7-88 through 10-89	1351	2076
LONG	Not available	807	1404
MONITOR	Not available	1351	2112
NEWARK	Not available	807	1404
PAHROC	11-84 through 8-86	807	1388
PENOYER	7-85 through 5-87	1623	2422
RAILROAD (4)	7-86 through 11-87	3255	4148
RALSTON	7-87 through 5-89	2983	4152
SNAKE (6)	7-85 through 4-88	3255	5687
SPRING	7-85 through 4-87	1623	2425
STONE CABIN	7-87 through 5-89	2711	4152
WHITE RIVER	7-85 through 1-87	3255	3810
UTAH			
DUGWAY	7-88 through 8-89	1895	3111
FISH SPRINGS FLAT	7-87 through 2-89	1351	2537
PINE	7-86 through 3-88	1623	2421
SEVIER / WHIRLWIND	7-87 through 8-89	1351 / 3255	2076 / 3685
TULE	7-87 through 2-89	3255	4146
WAH WAH	7-86 through 3-88	2439	3301

NOTE: A Estimated construction dates were received from the Ralph M. Parsons Company on 9 July 1980. The construction interval listed for each valley is based on contracts which frequently include more than one valley. Therefore, the actual construction period in any one valley may be less than the interval presented. The construction sequence is for a main operational base at Coyote Springs. The distribution of annual water use for a main operational base at Beryl or Milford would be similar although the dates would be different.

B Estimated probable water requirement includes various error factors applied to construction activities and does not represent minimum water requirements. The estimated probable requirement is based on 1 July Fugro National cluster layouts and includes water for a construction camp and plant in each valley except Delamar.

C Estimated maximum water requirements represent the quantity that has been requested in appropriation applications for construction of clusters, and includes a 30% increase in estimated probable water use and a 25% increase in the number of probable clusters in each valley.

1. Includes Steven's Basin.
2. Includes Alkali Spring Flat.
3. Includes that portion of Hamlin Valley in Utah.
4. Includes part of Reveille Valley.
5. Includes Patterson Valley.
6. Includes Pleasant Valley in Nevada and that portion of Pleasant and Snake valleys in Utah.

ESTIMATED MX WATER REQUIREMENTS FOR CLUSTER CONSTRUCTION NEVADA–UTAH

MX SITING INVESTIGATION

DEPARTMENT OF THE AIR FORCE – BMO

TABLE 3

FUGRO NATIONAL, INC.

relatively small and not included in the table. Water requirements for road construction during the cluster-construction phase are included in the table. The water requirements as shown in Table 3 are based on estimates as of 1 July 1980.

The shelter layout design is preliminary and will not be completed until 1981. The total and annual estimated ground-water appropriations are based on the projected requirements and include error factors for a possible increase in shelter clusters per valley and in estimated requirements per cluster. Also, the quantities of ground water for each valley include water for construction camps and batch and wash plants in each valley. Though only 18 valleys are anticipated to have such facilities at this time, the facilities are included in water requirement estimates for each valley at this time for conservatism.

As shown in the table, cluster-construction water use is scheduled to begin in Dry Lake Valley in 1984 with an estimated probable total of 3255 acre-feet (4.0 hm^3), will peak in 1988 with a possible total of approximately 34,348 acre-feet (34.5 hm^3) being used among 12 valleys, and will taper off to zero after 1989 under present-use estimates. Operational base construction is also scheduled during this period, however, final base sites have not been selected at this time. As a basis of comparison for MX water requirements, the greatest probable amount of water consumed in any one year from any MX siting valley is estimated to be 3255 acre-feet (4.0 hm^3). This is slightly more than the 3246 acre-feet (4.0 hm3) of water required to operate two

18-hole golf courses according to records supplied by the State of Nevada. Coalfired electrical generating stations, to generate 1000 MW of stations, to generate 1000 MW of electrical energy, require 12,000 to 53,000 acre-ft/yr (14.8 to 65.3 hm^3/yr) to meet the water requirements for wet cooling systems. MX water requirements per valley are small in comparison and, more importantly, peak MX water requirements are for a one- to two-year construction period only. The combined amount of ground-water appropriation requested in Nevada and Utah for Snake Valley is greater than the greatest probable use because of state legal constraints on the transfer of points of diversion across state lines which might present water supply difficulties during construction.

Operational water use has been divided into three categories: Operational Bases (OB), Deployment Area Service Centers (DASC), and surveillance/maintenance facilities. The final deployment mode and location has not been established for these operation stations at the time of this report. Several Operational Base systems are under evaluation at the present time. It is anticipated that approximately four DASCs will be required in the siting area. Based on current manpower needs and consumptive-use estimates, it is expected that each DASC will probably require less than 100 acre-feet (0.12 hm^3) of ground water per year. Surveillance/maintenance facilities will be small, housing only a few personnel. Operational water-use at these facilities will be very small. During actual operation of the missile system, the maximum annual water requirement in any siting valley is estimated to be only 510 acre-feet (0.63 hm^3), and most siting valleys will require considerably less than that amount.

2.4 IMPACT OF MX WATER WITHDRAWALS

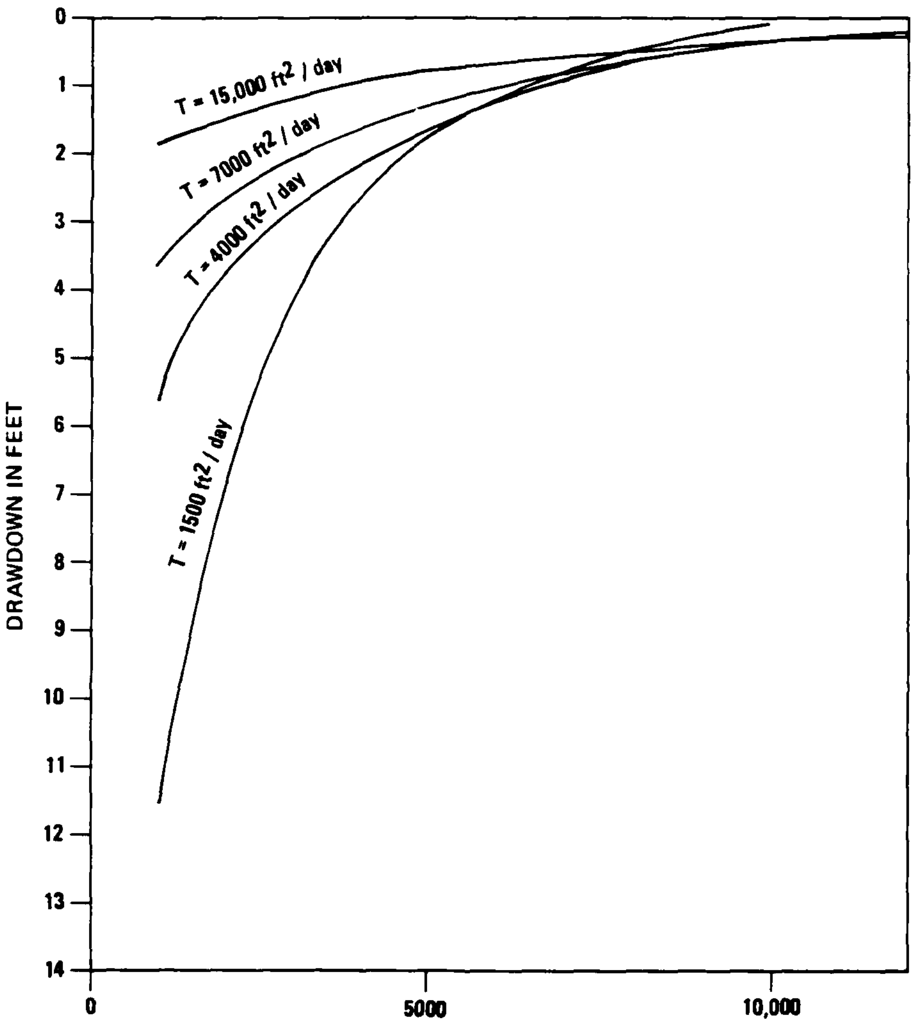
The impact of the development of ground-water supplies within an MX siting valley depends upon the hydrologic environment of the particular valley, the method, location, and rate of withdrawal.

MX development of the valley-fill aquifers may cause some temporary lowering of ground-water levels (potentiometric heads) in existing neighboring wells. The interference between wells is expected to be localized; the exact extent of the water-level decline is not precisely known for all valleys at this time. However, the impacts in any valley may be inferred to be approximately the same as those impacts which can be calculated for a similar valley but with a more complete data base. In an effort to better predict the impacts of MX ground-water withdrawals upon local water levels, numerical computer models have been developed to synthesize the ground-water regime in selected valleys. A two-dimensional, finite difference model for ground-water simulation has been applied to seven MX siting valleys. The results of the models indicate that, at a distance of 1 mile (1.6 kilometers [km]) from a typical MX water-supply well with a discharge ranging from 100 to 1000 gallons per minute (gpm), the ground-water levels are likely to only be lowered between 1 and 5 feet (0.3 and 1.5 m) over the scheduled one- or two-year pumping period, assuming a common storage coefficient of

0.1. Assuming a more pessimistic or conservative storage coefficient of 0.001, the drawdown would still generally be less than 5 feet (___m) but could, in isolated cases, reach 32 feet (___ m).

Figure 2 illustrates the estimated drawdown of the ground-water table with distance from a pumping well due to a likely pumping rate of 350 gpm (22.1 liters per second [l/s]) in typical aquifers with transmissivities of 1500, 4000, 7000, and 15,000 square feet per day (ft^2/day) (139, 372, 650, and 1394 square meters per day [m^2/day]) and storage coefficient of 0.1. The drawdown is projected to range from approximately 2 to 12 feet (0.6 to 3.7 m) within 1000 feet (305 m) of a proposed pumping well, to generally less than 1 to 2 feet (0.3 to 0.6 m) at a distance of approximately 5280 feet (1609 m). These distance-drawdown curves illustrate the effect different transmissivity values have on drawdowns.

It must be pointed out that 350 gpm (22.1 l/s) is probably an average rate of withdrawal. The pumping rate at each production well should be designed according to the transmissivity in order to minimize the drawdown in neighboring wells. In areas where the transmissivity is high, such as in areas of Railroad Valley, the pumping rate could be from 700 to 1000 gpm (44.2 to 63.1 l/s) and have minimal effect on the environment and local users. Conversely, in areas of low transmissivity, such as Delamar or Pine valleys, the rate of pumping could be from 100 to 200 gpm (6.3 to 12.6 l/s).



DISTANCE FROM PUMPING WELL (FEET)

NOTE: DISTANCE VERSUS DRAWDOWN FOR A WELL DISCHARGING 350 GPM FOR 2 YEARS FROM AN AQUIFER WITH A TRANSMISSIVITY OF 1500 TO 15,000 ft^2/day AND A STORAGE COEFFICIENT OF 0.1 ASSUMES A FULLY PENETRATING WELL IN AN INFINITE, HOMOGENEOUS, ISOTROPIC AQUIFER, AND SMALL DRAWDOWN RELATIVE TO AQUIFER THICKNESS'

THIS SIMULATION OF DRAWDOWN VERSUS DISTANCE WAS MADE BY THE TRESCOTT, PINDER, AND LARSON (1976) TWO-DIMENSIONAL FINITE DIFFERENCE MODEL WITH THE ASSUMPTION THAT A RECHARGE BOUNDARY IS PRESENT APPROXIMATELY 53,000 FEET FROM THE WELL LOCATION.

DISTANCE VERSUS DRAWDOWN FOR TYPICAL VALLEY - FILL AQUIFER CONDITIONS	
MX SITING INVESTIGATION DEPARTMENT OF THE AIR FORCE — BMO	FIGURE 2
FUGRO NATIONAL, INC.	

With increasing values of transmissivity, the drawdown extends a greater radial distance away from the well at any given time, but the amount of drawdown decreases. In other words, for a given rate of pumpage, the configuration of the cone of depression is broad and relatively flat for a productive aquifer and narrow and steep for an unproductive aquifer. Because wells for the MX project are expected to be located several miles apart, and where ever possible, several miles from existing wells and springs, the effects of drawdown on the existing wells and springs can largely be avoided or minimized through careful well placement. Thus, MX construction-water withdrawals are not expected to have a significant impact on the aquifer(s) or nearby water users. A reduction of spring discharge rates, however, could occur.

Pumpage from valley-fill aquifers have reportedly reduced the spring discharge from the carbonate aquifer in the Ash Meadows area of the Amargosa Desert. In other areas, however, large-scale, ground-water development has not affected spring discharges. This is the more common situation because most springs are located in the mountains and are recharged locally by meteoric sources (precipitation and snowmelt), while many other springs, located in the valley-fill deposits, are fed by perched aquifers or the regional carbonate aquifer and are not directly connected to the main valley-fill aquifer(s). Not only are most springs not in direct connection with the main aquifer, but the production wells will be located at a sufficient distance and generally down-gradient from spring areas to minimize the risk of impacts of MX withdrawals on springs or seeps and the wildlife within such areas in accordance with the state engineer's office.

Depending upon the approach used in obtaining a water supply, consumption by the MX missile system could either favorably or adversely affect water-supply quality in siting valleys. If water is obtained through the purchase or lease of existing irrigation-water rights, and if the irrigated land is temporarily retired from agriculture, it is likely that the total dissolved solids in the ground water will decline because the leaching action of irrigation water through the fertilized soils will have been decreased. Conversely, if the amount of ground water extracted is increased for MX needs and the rate of irrigation remains the same, the TDS concentration in the ground water would likely increase at about the same or at a slightly higher rate than the rate of increase of TDS concentration before the MX withdrawals. Nevertheless, no appreciable increase in adverse effects on ground-water quality from MX withdrawals is expected.

Construction of roads and shelters is expected to slightly increase surface-water runoff. Impervious surfaces constructed in the valleys, such as shelter rooftops, can create more runoff than natural conditions. The compaction of soil for road construction will alter the moisture holding and runoff characteristics of the soils; this will also increase runoff which can create higher flood peaks at downstream locations, such as road crossings.

In addition to the possible local impacts identified above, some regional impacts must be considered for areas that are not actually considered for MX siting purposes but are within the same regional flow system as MX sites. The Moapa Springs area provides a good example of such potential impact. Discharge rates at Moapa Springs are reported to be unaffected by local ground-water withdrawal from the valley-fill aquifer. It has been reported, however, that the 36,000 acre-ft/yr (44.4 hm^3/yr) discharged by Moapa Springs is water derived initially from 13 valleys within the White River flow system. Eight of these valleys are being considered as cluster- or base-siting areas and could require an annual ground-water extraction rate of 10,780 acre-feet (13.3 hm^3), based upon an average annual ground-water withdrawal of 4400 acre-feet (5.4 hm^3) for a primary base and 6380 acre-feet (7.9 hm^3) for cluster construction, during the peak construction-water use year. What impact such development would have on Moapa Springs or the water quality of the flow system is not precisely known. The degree of communication between the valley-fill aquifers and the carbonate flow system is the major uncertainty in evaluating the regional impact of the MX missile system. A test drilling program is in progress to evaluate the characteristics of the carbonate aquifers and their relationship to valley-fill aquifers.

It is possible, however, to estimate the effect pumping from the valley-fill aquifer would have on Moapa Springs by assuming a worse-case situation. For example, if 3810 acre-ft/yr (3.1 hm^3/yr) was pumped for two years from Dry Lake Valley, and if it is assumed that no recharge occurs to Dry Lake Valley (perennial yield is zero), and that all the water came from storage (assume specific yield of 0.01), then, the average water-level decline for all of Dry Lake Valley would be about 3.0 feet (0.9 m). The quantity of water discharging at Moapa Springs is a function of the area contributing to the recharge and the effective transmissivity of the ground-water system and the ground-water gradient. If the elevation difference between the existing ground-water table in Dry Lake Valley and the water surface at Moapa Springs is 2500 feet (762 m) and if the distance is 70 miles (112.7 km), the effective gradient would be:

$$\frac{2500 \text{ feet}}{70 \text{ miles}} \times \frac{1 \text{ miles}}{5280 \text{ feet}} = 0.006764$$

Assuming that pumping from Dry Lake Valley lowers the ground-water level 3.0 feet (0.9 m), then the new gradient would be 0.006756. Thus, assuming the maximum connection between Dry Lake Valley and the Moapa Springs, the assumed pumping could possibly lower the discharge in the springs by 0.08 percent. This would not be detectable over a two-year period.

In addition to the possible detrimental impacts discussed above, the development of water resources will also have a number of beneficial impacts. In many areas, the principal constraint to development of the arid, Great Basin valleys is the cost of developing an adequate water supply. The wells, reservoirs, and pipelines installed for MX will likely have an operational life in excess of 40 years. The water-supply system developed for MX construction may be available for many types of use including irrigation, municipal supplies, ranching, and fire control. In many areas, most of this system might become available soon after construction is completed. Although roads constructed for MX use will decrease grazing acreages, access will be greatly improved over the rangeland and will allow better herd control, increased water supplies, and better salt distribution.

3.0 GROUND-WATER CONDITIONS IN SELECTED VALLEYS

3.1 BIG SAND SPRINGS VALLEY

3.1.1 Physiography and Geology

Big Sand Springs Valley is in Nye County, Nevada. The valley trends north-south and is approximately 52 miles (84 m) long and 15 miles (24 m) wide at its widest point. The valley and surrounding mountains encompass an area of approximately 574 square miles (mi^2) (1487 square kilometers [km^2]), of which 250 mi^2 (648 m^2) are geotechnically suitable for MX deployment. Big Sand Springs Valley is also known as "the southern half of Little Smoky Valley" (Rush and Everett, 1966).

Big Sand Springs Valley is separated from Hot Creek Valley to the west and to the southwest by the Palisade Mesa, Halligan Mesa, and Squaw Hills. In the east and southeast, the Pancake Range separates the valley from Railroad Valley. Little Smoky Valley borders Big Sand Springs Valley to the northwest, and the drainage divide between the two valleys is a pediment formed by carbonate rocks of Paleozoic age (Rush and Everett, 1966).

The mountains bordering Big Sand Springs Valley to the west range in elevation from about 6000 to about 8000 feet (1829 to 2438 m). The highest point bordering the eastern side of the valley is Portuguese Mountain in the Pancake Range; its elevation is 9240 feet (2816 m). The lowest point on the valley floor is located on a playa near the southern edge of the watershed with an elevation of about 5600 feet (1707 m).

Volcanic rocks comprise most of the northern part of the Pancake Range, and carbonate rocks are dominant in the southern part (Rush and Everett, 1966). The topography of the southern end of Big Sand Springs Valley is influenced by recent volcanic craters and associated lava flows (Rush and Everett, 1966).

Evidence of volcanic activity in Big Sand Springs Valley is exemplified by the presence of the Lunar Crater in 6N/53E. The crater has a diameter of about 0.75 mile (1.2 km) and an approximate depth of 500 feet (152 m). It is believed that the volcanics in the southern portion of Big Sand Springs Valley are permeable and capable of transmitting ground water. However, little information is available on these rocks at this time.

The alluvial valley-fill deposits are late Tertiary and Quaternary in age and are composed primarily of unconsolidated or poorly consolidated gravels and sands derived from adjacent mountain ranges. Fluvial and lake deposits, which are Pleistocene in age, are composed of fine sands, silts, and clays which interfinger with older alluvial deposits in the center of the valley. Rush and Everett (1966) cite the presence of a probable Pleistocene lake in the southern end of the valley. Because no wells penetrate bedrock in the center of the valley, the total thickness of the alluvial deposits is not known.

3.1.2 General Hydrology

3.1.2.1 Surface Water

Surface water in Big Sand Springs Valley is derived from precipitation on the valley floor and in the surrounding mountain areas. The maximum precipitation was estimated to be 15 to 20 inches per year (inches/yr) (380 to 510 millimeters per year [mm/yr]) in areas above about 9000 feet (2743 m). The minimum rainfall generally occurs in areas below 7000 feet (2134 m) and is estimated to average less than 8 inches/yr (203 mm/yr) (Rush and Everett, 1966). For the entire drainage area, Rush and Everett (1966) estimated that the total basin-wide precipitation averages about 200,000 acre-ft/yr (247 hm^3).

Big Sand Springs Valley is a topographically closed basin with no surface-water outflow to other valleys. No streamflow was observed on the valley floor during a field reconnaissance by Fugro National in May 1980.

A method to estimate surface-water runoff in Nevada where no streamflow data are available was cited by Eakin and others (1965). The method is based on the general condition that areas at higher altitudes receive more precipitation than those at lower altitudes. As a result, the higher altitude areas are also assumed to produce greater amounts of runoff. Because the relationship between precipitation, altitude, and runoff throughout the various parts of Nevada vary, different correlation factors are used to adjust the altitude-runoff relation for the several mountain areas. The adjustment is based on streamflow measurements, differences in vegetation, amounts of precipitation, and geology. Using this method, Rush and Everett (1966) estimated the runoff in Big Sand Springs Valley, at the bedrock-alluvium contact, to be 1500 acre-ft/yr (1.8 hm^3/yr).

3.1.2.2 Ground Water

Ground-water withdrawals occur primarily from the valley-fill aquifer which is recharged for the most part from infiltration in the surrounding mountains and, to a much lesser extent, by direct precipitation on the valley floor. Total recharge from within the valley is estimated to average about 1400 acre-ft/yr (1.72 hm^3/yr) (Rush and Everett, 1966). Subsurface inflow from northern Hot Creek Valley to Big Sand Springs Valley through carbonate rocks is estimated to be about 10,000 acre-ft/yr (12.3 hm^3/yr).

Based on a very limited number of sampling points, two potentiometric contours were constructed for Big Sand Springs Valley (Drawing B1-1). Wells used to obtain water-level measurements in the construction of the map are all located in the southern portion of the valley and believed to be completed at depths less than 2500 feet (762 m) below land surface (Dinwiddie and Schroder, 1971). Depths to ground water in these wells ranged from 240 feet (73 m) to greater than 600 feet (183 m) below land surface. However, no information was available on water levels in the northern portion of the valley. The potentiometric map indicates that ground-water flow is in a northeasterly direction in the southern portion of the valley. Ground water is not discharged by evapotranspiration from phreatophytes or agricultural activities in Big Sand Springs Valley. Rush and Everett (1966) indicated that flow in the southern portion of Little Smoky Valley (Big Sand Springs Valley) is generally eastward toward Railroad Valley where ground water is discharged through springs. The investigation also estimated that the subsurface outflow through carbonate rocks to Railroad Valley is about 12,000 acre-ft/yr (14.8 hm^3/yr).

The volume of water stored in the upper 100 feet (30.5 m) of the saturated alluvium was estimated to be 940,000 acre-feet (1159 hm^3) (Rush and Everett, 1966). This estimate is based on the assumption that 94,000 acres (3804 hm^3) constitute the surface area of the aquifer with greater than 100 feet (30.5 m) of saturated valley fill and a specific yield of 10 percent (Rush and Everett, 1966). The estimate of specific yield agrees with generalized values for valley-fill aquifers. The estimated perennial yield of Big Sand Springs Valley is 1000 acre-feet (1.2 hm^3) (Rush and Everett, 1966).

This value is based on the potential for salvaging all or part of the 2000 acre-ft/yr (2.5 hm^3/yr) ground-water recharge in Big Sand Springs Valley that is hypothesized to discharge by underflow to springs near Lockes 8N/55E in Railroad Valley. The perennial-yield estimate does not consider an additional estimated 10,000 acre-ft/yr (12.3 hm^3/yr) of ground-water discharge to Railroad Valley which is received by Big Sand Springs Valley from Hot Creek Valley as recharge in the regional carbonate aquifer.

The possibility of salvaging the 2000 acre-ft/yr (2.5 hm^3/yr) discharge by pumping in Big Sand Springs Valley is dependent on the mechanism of subsurface outflow. If ground water is moving over a "spillway" in the volcanic rocks of the Pancake Range, the reduction of water levels in Big Sand Springs Valley to below the "spillway" will make the complete salvaging of ground-water discharge possible. However, if subsurface outflow is through vesicular openings, joints, and deep faults in the volcanics, the possibility and success of salvaging discharged ground water is substantially reduced. As a result, Rush and Everett selected a value of perennial yield between the two extremes.

3.1.3 Aquifer Characteristics

Most wells drilled in Big Sand Springs Valley are relatively shallow and are used for stock water. Unfortunately, these wells use low-capacity piston pumps which are generally unsuitable for aquifer testing. Therefore, aquifer testing of existing wells was not conducted as part of the Fugro National field investigations, and neither the transmissivity nor the storage coefficient of the valley-fill aquifer could be computed. According to Rush and Everett (1966), most of the ground water in Big Sand Springs Valley is stored in unconsolidated, undissected, and relatively undisturbed alluvium. A well is scheduled to be drilled in Big Sand Springs Valley as part of the Fugro National FY 81 drilling program. Upon completion, an extensive aquifer test will be performed to help determine transmissive and storage characteristics of the valley-fill deposits. Interbasin ground-water flow indicates that volcanic rocks in the southern part of Big Sand Springs Valley are permeable and are capable of transmitting ground water.

3.1.4 Water-Quality Limitations

Only one sample for water-quality analyses was collected by Fugro National in Big Sand Springs Valley. This sample, obtained from Squaw Wells Spring at 10N/52E-23aa, was principally a calcium-magnesium-sodium/bicarbonate type water and was rated as good in quality based on the criteria listed in Table C1-1. A total of eight additional samples were collected from various depths at various times in three wells by the Nuclear Regulatory Commission in this valley (Table 1-2). For the purpose of this report, only the last sample collected at the shallowest depth in each well was considered. Based on the criteria listed in Table C1-1, each of these samples is considered to be of poor quality (Drawing D1-1). However, these samples were obtained from relatively great depths (870 feet to 6500 feet [265 to 1981 m]) where the ground water has generally been in contact with the formation for long periods of time. Any ground water in this area, that is above the depth tested, is likely to be of better quality.

3.1.5 Potential Impacts of MX Water Resources Development

As shown in Table 2 (Summary of Ground-Water Availability) perennial yield for Big Sand Springs Valley (southern Little Smoky Valley) is 1000 acre-ft/yr (1.2 hm^3/yr). Current ground-water withdrawal is near zero. Therefore, nearly 1000 acre-ft/yr (1.2 hm^3/yr), or the total perennial yield, is available. It is estimated that about 1351 acre-ft/yr (1.7 hm^3/yr) will be required for MX needs (Table 3) indicating a water deficit of about 351 acre-ft/yr (0.4 hm^3/yr). Considering the total storage capacity of the Big Sand Springs Valley alluvium of 940,000 acre-feet (1159 hm^3), a short-term overdraft of 351 acre-ft/yr (0.4 hm^3/yr) for a one- or two-year period should have no significant impact on the aquifer or other water users in the valley. In addition, if a portion of the estimated ground-water discharge to Railroad Valley can be captured by pumping, then there is not expected to be any long-term deficit.

3.2 COAL VALLEY

3.2.1 Physiography and Geology

Coal Valley is situated in eastern Nye County, northwestern Lincoln County, in southeastern Nevada (Figure 1). The valley and tributary drainage basin has a total area of 447 mi^2 (1158 km^2) of which approximately 280 mi^2 (725 km^2) are suitable for MX siting. The valley trends north-south and is approximately 40 miles (64 km) long and 15 miles (24 km) wide. The valley is bordered on the west by the Golden Gate Range, on the east by the Seaman Range, and on the south by the north Pahranagat Range. In the north, a low topographic divide of valley-fill deposits separates Coal Valley from Garden and White River valleys. Garden Valley is located west of Coal Valley across the Golden Gate Range.

Elevations within the Coal Valley watershed range from a low of about 5000 feet (1524 m) to a high of 8741 feet (2664 m) on Mount Irish in the north Pahranagat Range. Mountain crests along the east edge of the valley range from 6200 feet to 8650 feet (1890 m to 2637 m); elevations in the Golden Gate Range along the west edge vary from about 6000 feet to about 7000 feet

(1829 to 2134 m). During Pleistocene time, a shallow lake occupied the floor of Coal Valley. As a result, a playa deposit occupies much of the central portion of the valley. The playa elevation is about 5000 feet (1524 m).

At the present time, the valley is topographically closed, although it appears that during Pleistocene times there was surficial drainage through Seaman Wash (elevation 5000 feet [1524 m]) into White River Channel in the southeast part of the valley. A low alluvial divide presently separates Seaman Wash from the playa.

According to Eakin (1963), the valley-fill deposits are divided into two units: older and younger valley-fill deposits. The older unit consists mainly of unconsolidated to partly consolidated silt, sand, and gravel derived from adjacent highland areas. Some rocks of volcanic origin are included in this unit, which ranges from Tertiary to Quaternary in age. The unit was deposited largely under subaerial and lacustrine environments and is probably several thousand feet thick. The younger unit, which is probably not more than a few hundred feet thick, consists of unconsolidated clay, silt, sand, and gravel of late Quaternary age. The valley-fill material is probably underlain by bedrock similar to that exposed in the mountains.

3.2.2 General Hydrology

3.2.2.1 Surface Water

Surface water periodically flows in Cherry Creek during times of high runoff from the Grant and Quinn Canyon ranges across Garden

Valley and into Coal Valley through the gap located in 2N/59E. In the early 1900s, a dam was constructed in Coal Valley just south of the divide, but there was insufficient runoff to sustain irrigation in the area. During the Fugro National field reconnaissance in June 1980, flow through the divide was measured at 40 gpm (2.5 l/s), and five days later estimated at less than 1 gpm (0.06 l/s).

3.2.2.2 Ground Water

The only wells that penetrate the water table are located in the hills in the southern part of Coal Valley (2S/58E-12bb and 2S/60E-5cd). The ground water in these areas is considered to be "perched." Therefore, although a 150-foot (46-m) depth-to-water and a 50-foot (15-m) depth-to-water contour have been extrapolated around these two respective wells in an effort to delineate the exclusion zone for MX cluster construction, the actual limits of these zones may differ considerably.

Because there are no wells tapping the saturated valley-fill deposits in Coal Valley, there are no potentiometric surface contours on Drawing B1-2. Based on the study conducted by Carpenter (1915), ground water under the playa is at a depth in excess of 250 feet (76 m) in the central part of Coal Valley, greater than 160 feet (49 m) in the north, and more than 190 feet (58 m) in the south. Eakin (1963) stated that ground water is flowing out of Garden Valley into Coal Valley and out of Coal Valley in a southerly direction toward Pahranagat Valley. At 5000 feet (1524 m), the floor of Coal Valley is about

1000 feet (305 m) higher than the northern end of Pahranagat Valley located 8 to 10 miles (13 to 16 km) to the south.

Recharge from precipitation and runoff is estimated by Eakin (1963) to be 2000 acre-ft/yr (2.5 hm^3/yr). There is no discharge from wells or phreatophytes, and spring discharge along the valley flanks is considered minor. Because Garden and Coal valleys appear to be hydraulically connected, the 2000 acre-ft/yr (2.5 hm^3/yr) recharge can be combined with the 10,000 acre-ft/yr (12.3 hm^3) recharge from precipitation in Garden Valley. Total recharge for both valleys from precipitation and runoff would then be estimated at 12,000 acre-ft/yr (14.8 hm^3/yr). As is noted in the Garden Valley study (included in this report), ground-water inflow to both Garden and Coal valleys probably occurs from White River Valley, but the inflow is probably to the regional carbonate system and is not included in the perennial-yield calculations.

Eakin (1963) believed that the ground-water movement in Coal Valley has a more southerly component than the ground-water movement in Garden Valley. He suggested that the depth to water beneath the playa is about 500 feet (152 m) and may possibly be as much as 1000 feet (305 m) beneath the southeast part of the playa.

3.2.3 Aquifer Characteristics

There have been no aquifer (pump) tests performed in Coal Valley because all the deep wells in the valley floor are dry. Therefore, it is not possible to calculate transmissivity and storage coefficient values for the valley-fill or carbonate aquifers at the present time. As is the case with Garden Valley, the valley fill is composed of fine sand and silt deposits having relatively low permeability. Some amount of consolidation or cementation of grains may further reduce the ability of the aquifer to transmit water.

3.2.4 Water-Quality Limitations

Only one water-quality sample was collected by Fugro National personnel during the field reconnaissance in FY 80 (because of the lack of suitable wells). This sample was obtained from a 3-to-4-gpm spring (1N/61E-29ca) in the Seaman Range on the eastern side of the valley. As shown in Table C1-3 and Drawing D1-2, the water sample analyzed was classified as a calcium-magnesium-sodium/bicarbonate type water. Based on a calcium value of 82 mg/l, the water is rated poor. This spring flow is believed to be recharged locally in the Seaman Range which is composed primarily of carbonate rocks. Solution of these rocks is the probable source of the moderately high calcium content found in the analysis. However, based on many analyses in other valleys, it is felt that this analysis may not be representative of the quality of water in the valley-fill aquifer.

3.2.5 Potential Impacts of MX Water Resources Development

Eakin (1963) estimated recharge from precipitation and runoff at 2000 acre-ft/yr (2.5 hm^3/yr) with no discharge resulting from pumping or evapotranspiration. Excluding the suspected groundwater underflow entering the regional carbonate aquifer from

White River Valley, the perennial yield is estimated to be half of the combined 12,000 acre-ft/yr (14.8 hm^3/yr) perennial yield for Coal and Garden valleys, or 6000 acre-ft/yr (7.4 hm^3/yr). This quantity is reasonable since ground water from Garden Valley discharges into Coal Valley. However, if the additional ground water hypothesized as entering Garden Valley from White River Valley is correct, the resultant perennial yield of Coal Valley would be significantly greater. Although the probable amount of ground water needed for MX construction (2125 acre-ft/yr [2.6 hm^3/yr]) may slightly exceed the estimated recharge from precipitation and recharge, this value would be substantially less than the estimated perennial yield of the valley. Additionally, Eakin (1963) stated there is also a substantial amount of ground water in storage in the valley fill. This source could provide water for MX construction needs with minimum impact on other users.

Considering the regional carbonate aquifer flow from Garden Valley to Coal Valley as noted in Section 3.3.2.2, the regional carbonate aquifer in Coal Valley may contribute an additional 8000 to 12,500 acre-ft/yr (9.9 to 15.4 hm^3/yr). This is an alternative ground-water source that might supply water needed for MX construction with little or no impact on other water users but would likely be difficult and expensive to develop.

At the present time, there are no certificates or proofs for ground-water withdrawal in Coal Valley (Cochran, 1980). Permits and applications have been filed for 6515 acre-ft/yr (8.0 hm^3/yr) by individuals and private enterprises. These permits and applications have established a priority date and could eventually become valid water rights resulting in the possible appropriation of the entire perennial yield.

Because MX development would require only 2167 acre-ft/yr (2.7 hm^3/yr) for a one- or two-year period of time, and because there are no present water users, MX withdrawals would produce a minimal impact on the aquifer and the valley water resources. If permits and applications are fully developed, the potential for impacts would be increased and water supply alternatives, such as lease or purchase of existing rights or importation of water from White River Valley, could be implemented.

3.3 GARDEN VALLEY

3.3.1 Physiography and Geology

Garden Valley is situated in eastern Nye County and northwestern Lincoln County in southeastern Nevada. The valley has a total area of 508 mi^2 (1316 km^2) of which approximately 227 mi^2 (588 km^2) are suitable for MX siting.

Garden Valley is a north-south trending valley with a length of approximately 50 miles (80 km) and a width varying from 5 to 21 miles (8 to 34 km). The valley is bordered on the northwest by the Quinn Canyon and Grant Ranges, on the southwest by the Worthington Mountains, and on the east by the Golden Gate Range. A low topographic divide of valley-fill materials separates Garden Valley from Penoyer Valley (also known as Sand Spring Valley) to the southwest. A small gap at 2N/59E in the Golden

Gate Range allows surface flows from Garden Valley to enter Coal Valley to the east.

Elevations within the Garden Valley watershed range from a low of about 5200 feet (1585 m) to a high of 11,298 feet (3444 m) at Troy Peak in the extreme north end of the watershed. In general, mountain crests along the western side of the watershed range from about 9000 to about 11,000 feet (2743 to 3353 m). On the east, elevations generally range from about 6000 to about 7000 feet (1829 to 2134 m), and on the southern end, mountain elevations are about 8000 feet (2438 m). The valley floor ranges in altitude from about 5200 feet to about 6200 feet (1585 to 1890 m).

According to Eakin (1963), the valley-fill deposits consist mainly of unconsolidated to partly consolidated silt, sand, and gravel derived from adjacent highland areas. These deposits also include some rocks of volcanic origin. The valley fill, which ranges in age from Tertiary to Quaternary, was deposited largely under subaerial and lacustrine environments and is probably several thousand feet thick.

The valley fill in Garden Valley corresponds to the older valley-fill unit described for Coal Valley. These sediments consist of relatively coarse-grained sediments and are the primary valley-fill aquifers for both valleys. According to Eakin (1963), the relatively thin, fine-grained sediments known as the younger valley fill are found only in Coal Valley.

The bedrock of the surrounding mountains has been divided into two units; the first consists of carbonates of Paleozoic age, and the second is composed mainly of clastics (shale, sandstone, quartzite, and conglomerate) of Paleozoic age and volcanics (welded tuff) of Tertiary age. The water-transmitting characteristics of both bedrock units are highly dependent upon the degree of secondary permeability (fractures and solution openings). Although the first unit is believed to play an important role in ground-water outflow from Garden Valley, little information is currently available on the transmitting characteristics of the second unit. The bedrock underlying the sedimentary deposits within the valley is believed to be similar to that exposed in the surrounding mountains (Eakin, 1963).

3.3.2 General Hydrology

3.3.2.1 Surface Water

Garden Valley is topographically open to the east through an area in the Golden Gate Range (2N/59E). Runoff from the Quinn Canyon and Grant ranges occasionally flows through this area into Coal Valley by way of several intermittent streams. Several streamflow measurements were made by Fugro National during the field reconnaissance in June 1980. Measurements by Fugro National of Cottonwood Creek (3N/56E-33c) and Cherry Creek (3N/57E-33c) averaged about 850 gpm and 1000 gpm (53.6 l/s and 63.1 l/s), respectively. Many springs and streams were inaccessible due to poor road conditions during the reconnaissance. Therefore, it was not possible to gauge total flow in the area. In June 1980, surface flow in Cherry Creek at 2N/59E-17a in the low divide between Garden and Coal valleys was measured at 40 gpm (2.5 l/s), however, five days later it was estimated at less than 1 gpm (<0.06 l/s). Personal communications with several of the ranchers indicate that Cherry Creek is perennial in Garden Valley although surface runoff only reaches the low divide and flows into Coal Valley in the spring and early summer months.

3.3.2.2 Ground Water

According to Eakin (1963), the ground water in Garden Valley is derived largely from precipitation in the Quinn Canyon and Grant ranges with lesser amounts contributed from the Worthington Mountains. Recharge from the Golden Gate Range is minor and largely occurs in the southern part of the range. Ground-water recharge from precipitation and surface runoff is estimated at 10,000 acre-ft/yr (12.3 hm^3/yr). Discharge from springs, phreatophytes, and wells in the valley probably does not exceed 1500 to 2000 acre-ft/yr (1.8 to 2.5 hm^3/yr). The remaining 8000 acre-ft/yr (9.9 hm^3/yr) of recharge from within this basin is believed to flow out of Garden Valley through the carbonates into Coal Valley.

According to Fugro National's study of the White River Valley (northeast of Garden Valley), 18,000 acre-ft/yr (22 hm^3/yr) of recharge is not accounted for in the ground-water budget. This quantity is believed to be discharged from the valley-fill deposits to the regional carbonate aquifer and migrates from White River Valley by subsurface outflow. It is believed that ground water in the regional carbonate aquifer flows at substantial depths under Garden and Coal valleys and discharges in valleys to the south. Thus, flow in the regional carbonate aquifer is not considered in the determination of perennial yield for either of these valleys.

Eakin (1963) believed that ground water leaves the valley and flows southeast toward Pahranagat Valley. The Golden Gate Range, along the eastern two-thirds of the valley, is apparently not a boundary to subsurface flow.

As shown in Drawing B1-3, ground water in the valley-fill aquifer generally flows in a southeast direction with a maximum potentiometric gradient of about 43 feet per mile (ft/mi) (8.1 meters per kilometer [m/km]). This gradient was measured from the Grant Range on the west to the Golden Gate Range on the east side of the valley. Ground-water levels range from 500 feet (152 m) below land surface in the southern part of the valley to near land surface in the northern part. In general, it is believed that ground-water flow is toward the east-southeast in Garden Valley where the ground-water discharges to Coal Valley and continues toward the south and Pahranagat Valley.

3.3.3 Aquifer Charactersitics

Because there have been no aquifer tests performed in Garden Valley, it is not possible to calculate transmissivity and storage coefficient values for the valley-fill or carbonate aquifers directly. According to Eakin (1963), most of the valley fill is composed of deposits of fine sand and silt having relatively low permeability. In addition, some of the valley fill is moderately consolidated or cemented which further reduces the capacity to transmit large quantities of water to wells. Using the potentiometric map and the estimated recharge, an approximation of the transmissivity can be made using the Darcy equation of Q = TIL, where:

Q is quantity,
T the transmissivity,
I the hydraulic gradient (taken from the potentiometric surface), and
L the width through which flow occurs.

It is estimated that 70 percent of the total recharge from streamflow loss and precipitation occurs across that portion of the valley described by the potentiometric lines in Drawing B1-3. Therefore, Q = 70 percent of 10,000 acre-ft/yr (12.3 hm^3/yr); I = 43 ft/mi (8.1 m/km); and L = 30 miles (48 km). The average transmissivity through the valley is calculated to be 648 ft^2/day (60.2 m^2/day). This value is reasonable and useful for conceptualizing well yields and drawdown effects. The storage coefficient, if water table conditions prevail, would be about 0.1 based on the general lithology.

A test well and observation well have recently been drilled in Garden Valley (2N/57E-15) by Fugro National. These wells were designed based on data obtained from geophysical and lithological logs of the initial or pilot hole. The test well consists of 970 feet (296 m) of 10-inch (25-centimeter [cm]) I.D. casing with the screened intervals from 830 to 880 feet and 890 to 950 feet (253 to 268 m and 271 to 290 m). The observation well consists of 1033 feet (315 m) of 2-inch (5-cm) I.D. steel casing with perforations generally between 820 and 1011 feet (250 and 308 m). The depth to water was measured at 431 feet (131 m) below land surface in the observation well nine hours after development procedures were completed. Both wells will be utilized conjunctively in an extensive aquifer test to help define the storage and transmission characteristics of the valley-fill aquifer. However, to date, testing is not complete.

3.3.4. Water-Quality Limitations

Fugro National personnel collected ground-water and surface-water samples for water-quality analyses from four wells, four creeks, and two springs in Garden Valley during the field reconnaissance of June 1980 (Table C1-4 and Drawing D1-3). Based on the water-quality criteria listed in Table C1-1, all of the samples collected were found to be within the recommended limits of water quality. However, the two samples collected at 1N/57E-20 were rated as poor quality because of the relatively high concentration (between 75 and 200 milligrams per liter [mg/l]) of calcium detected (Table C1-4). One of the samples collected at 1N/57E-20 was also found to have a relatively high concentration of fluoride (1.3 mg/l). Most of the samples collected were found to be a calcium-magnesium/bicarbonate type of water.

A water sample from the southern Uhalde well (1S/57E-2bb) is conspicuously low in calcium and magnesium and is classified as a sodium-bicarbonate type water. This sample also had a nitrate concentration of 9.4 mg/l which indicates the potential for localized ground-water contamination even though the analysis was within the criteria listed in Table C1-1. The overall quality of water for Garden Valley is good. Total dissolved solids concentrations are fairly low, reflecting a close proximity to the recharge area.

3.3.5 Potential Impacts of MX Water Resources Development

The perennial yield for Garden Valley has been estimated at 6000 acre-ft/yr (7.4 hm^3/yr) (State of Nevada, 1971). Eakin (1963) considered that the great depths to water and the costs involved in pumping from such levels prohibited large-scale withdrawals from the valley-fill or carbonate aquifers. He also believed that the water stored in these aquifers is many times the average annual recharge and discharge of the ground-water reservoir. Elsewhere in his report, as previously mentioned, Eakin estimated recharge from precipitation at 10,000 acre-ft/yr (12.3 hm^3/yr), and discharge from evapotranspiration, springs, and wells to be approximately 2000 acre-ft/yr (2.5 hm^3/yr). If this estimate is accurate, the estimated probable MX construction-water requirement of 2167 acre-ft/yr (2.7 hm^3/yr) and the estimated maximum construction water requirement of 3456 acre-ft/yr (4.3 hm^3/yr) will not exceed the average annual recharge from precipitation and would have no significant impact on the aquifer, the environmen , or local water users. However, the accuracy of these figures is open to discussion (see Section 3.2, Coal Valley).

According to the Desert Research Institute report, "Inventory of Water Rights and Water Use in the MX Siting Area" (1980), at the present time, 91 acre-ft/yr (0.1 hm^3/yr) of ground water is being pumped from the valley-fill aquifer for stock and irrigation purposes. However, water rights certificated amount to 395 acre-ft/yr (0.49 hm^3/yr), and extractions of an additional 5760 acre-ft/yr (7.1 hm^3/yr) have been requested by permit or application. If perennial yield is 6000 acre-ft/yr (7.4 hm^3/yr), and if the State of Nevada eventually grants the indicated permits and applications, then the valley would be fully appropriated. However, there is at present sufficient water available to supply MX construction needs for the one- or two-year period of use. If permits and applications for water are fully developed, then an alternative source of construction water could come from lease or purchase of existing rights, importation of water from White River Valley, or development of the carbonate aquifer.

3.4 LAKE VALLEY

3.4.1 Physiography and Geology

Lake Valley is primarily in northern Lincoln County with a portion in White Pine County in east-central Nevada (Figure B1-4). Lake Valley, as discussed in this report, includes both Lake and Patterson Valley hydrographic basins. The basin includes about 960 mi^2 (2486 km^2) of which about 340 mi^2 (881 km^2) are suitable for MX deployment. Lake Valley is a north-south trending basin approximately 65 miles (105 km) long with an average width of about 16 miles (26 km) and a maximum width of about 21 miles (34 km).

The valley is bounded by the Fortification Range on the northeast and east, by the Wilson Creek Range on the southeast, by the Schell Creek Range on the west and northwest, by the Fairview, Bristol, and Highland ranges on the southwest, and by the Pioche Hills on the south. Elevations in the watershed range from a low of about 5500 feet (1676 m) near the southeast edge of the basin to a high of 10,993 feet (3351 m) at Mount Grafton in the Schell Creek Range.

Quartzite and shale of Paleozoic age are the principal rocks exposed in the Schell Creek Range with minor outcrops of volcanic rocks of Tertiary and Paleozoic ages. Volcanics are the most abundant rocks of the Wilson Creek and Fortification ranges, however, carbonate rocks are also common in the northern part of the Fortification Range. Carbonate rocks, largely limestone and dolomite, are exposed in the Bristol and Highland ranges.

Deposits composing the valley-fill materials range from Tertiary to Quaternary in age. The valley fill consists of younger unconsolidated clay, silt, sand, and gravel, and older, partly consolidated pyroclastic deposits of welded tuff and sedimentary deposits. The subsurface lithology and water-bearing properties of the rocks are not well known. However, it is inferred that the deposits of Quaternary age were laid down under subaerial and lacustrine environments. Deposits in the lakes suggest that beds of fine-grained material might have fairly extensive lateral continuity. The rocks of Tertiary age underlying the

Quaterary deposits are believed to be similar in character to the rocks of Tertiary age exposed in the mountains.

In the southern part of Lake Valley, the alluvial fans bordering the Bristol Range on the west and the Wilson Creek Range on the east nearly merge along the axis of the valley, resulting in the development of a very narrow flood plain. The maximum width of the flood plain is about 1 mile (1.6 km). The plain slopes southward 30 to 60 ft/mi (5.7 to 11.4 m/km) in this area.

3.4.2 General Hydrology

3.4.2.1 Surface Water

Streamflow within Lake Valley is derived from snowmelt runoff, ground-water discharge, and runoff from infrequent summer rainstorms. Streams on the valley floor are ephemeral, although a few mountain streams are perennial. Runoff from the mountains is rapidly absorbed by the alluvial fans which recharge the ground-water supply. A minor amount of runoff reaches the valley floor, generally in response to infrequent, but intense, summer rainstorms.

Topographically, two separate drainage basins exist in Lake Valley. The northern area is an enclosed basin and produces the greater average annual runoff which has been estimated to be 8000 acre-ft/yr (9.9 hm^3/yr) (State of Nevada, 1971). The southern area (Patterson Valley) is an open drainage basin with minor outflow southward to Panaca Valley. The average annual runoff produced in this southern area is estimated to be 3300 acre-ft/yr (4 hm^3/yr) (State of Nevada, 1971).

No continuous streamflow records have been collected in Lake Valley; however, the mountain streams are believed to share the same seasonal characteristics as Cleve Creek in Spring Valley (Figure 3). Three perennial streams in the northern portion of the valley, Geyser Creek, North Creek, and Wilson Creek, can be expected to produce snowmelt runoff beginning in March or April and experience peak flows in May and June. Low-base flow, sustained primarily from ground-water discharge, is typical from late summer through early spring. Runoff from infrequent rainstorms can be expected to produce flash-flood peaks on occasion, but the total amount of water discharged from such events is minor compared to runoff from other sources.

Streamflow in the southern portion of Lake Valley is predominantly ephemeral, with snowmelt runoff of short duration and long periods of no flow. An occasional, intense summer rainstorm may produce sufficient runoff to flow out of the valley via Patterson Wash.

3.4.2.2 Ground Water

Drawing B1-4 illustrates the potentiometric surface and depth to water in the valley-fill deposits of Lake Valley. Interpretations on the map are based on published water-well information and measurements by Fugro National during FY 79. As shown, approximately 25 percent of the northern section of the valley has water at depths less than 50 feet (15 m) beneath the ground surface. Less than 10 percent of the southern section of the valley has water at less than 50 feet (15 m). The potentiometric surface slopes at an average gradient of about 4 ft/mi

(7.6 m/km) to the south to the topographic divide at about township 5N. From this point south to Pioche and the entrance to Panaca Valley, the average slope is about 15 ft/mi (2.8 m/km).

Aquifer recharge is from direct infiltration of precipitation, surface runoff, and subsurface underflow from fractured or solutioned volcanic and/or carbonate bedrock. Recharge by direct infiltration is estimated to be 13,000 acre-ft/yr (16 hm^3/yr) in the northern section of the valley and 6000 acre-ft/yr (7.4 hm^3/yr) in the southern valley area (Patterson Valley) (Nevada State Engineer, 1971). The coefficient of transmissivity was calculated to range from 16,000 to about 21,400 ft^2/day (1490 to 1987 m^2/day) (Rush and Eakin, 1963). The range of values was obtained by multiplying the known specific capacity of wells (in gallons per minute per foot of drawdown) by an empirical factor that ranges from 1500 to 2000. An estimate of underflow from the northern part to the southern part of Lake Valley can be made using the Darcy equation listed in Section 3.3.3.

Considering the hydraulic gradient to be 15 ft/mi (2.8 m/km) from drawing B1-4, transmissivity to be 18,700 ft^2/day (1740 m^2/day), and an effective width of ground-water flow of about 1 mile (1.6 km), underflow from the northern to southern section has been estimated to be 2400 acre-ft/yr (3.0 hm^3/yr). This estimate was revised to 3000 acre-ft/yr by the Nevada State Engineers office in 1971.

Discharge from the valley-fill aquifer is by evapotranspiration from phreatophytes and wells, springs, and subsurface outflow.

Discharge by evapotranspiration is estimated to be about 8500 acre-ft/yr (10.5 hm^3/yr) (Rush and Eakin, 1963). The estimated perennial yield of Lake Valley is about 17,000 acre-ft/yr based on the estimate of average annual ground-water recharge and discharge.

Discharge from the valley-fill aquifer by springs is considered minor. Subsurface outflow through the southern section of Lake Valley into Panaca Valley is about 9000 acre-ft/yr (11.1 hm^3/yr) (Rush, 1964). The outflow occurs primarily through carbonate rock underlying the alluvium in the southern end of Lake Valley. Although there are numerous intermittent springs on the mountain sides, these are not included in the water budget because the discharges are from perched ground-water bodies rather than the valley-fill aquifer (Rush and Eakin, 1963).

3.4.3 Aquifer Characteristics

Ground water is contained primarily in the alluvial valley-fill deposits. This aquifer consists of unconsolidated sand and gravel deposits separated by irregularly shaped lenses of clays. The ages of these deposits range from Quaternary near the surface to mid-Tertiary in the deeper sediments. Underlying the deposits of Quaternary age are several thousand feet of volcanics of Tertiary age. These rocks have a limited capacity to transmit water through fractures. Beneath the volcanics is the carbonate aquifer about which little is known. The carbonate aquifer transfers ground water from southern Lake Valley to Panaca Valley. Water percolates through fractures, joints, and solution cavities in the carbonate rocks with some discharge occurring at Panaca Spring (2S/68E-4).

Information regarding aquifer characteristics of Lake Valley is limited. However, drillers' aquifer tests on two wells, 6N/66E-22b1 and 6N/66E-22b2, drilled to depths of 510 feet and 400 feet (155 and 122 m), respectively, each yielded 2400 gpm (151 l/s) with a drawdown of 30 feet (9 m). From this data, the transmissivity has been estimated to be about 17,400 to 21,400 ft^2/day (1624 to 1987 m^2/day) indicating the aquifer is productive. Ground-water storage has been estimated for the upper 100 feet (31 m) of the saturated valley fill in the valley to be 3,600,000 acre-ft (4439 hm^3) (State of Nevada, 1971).

The perennial yield, as previously stated, has been estimated at 12,000 acre-feet (14.8 hm^3) for northern Lake Valley and about 5000 acre-feet (6.2 hm^3) for southern Lake Valley. Because the perennial yield of the southern part of Lake Valley is largely dependent upon the quantity of recharge from the northern part, significant pumping in the north may substantially reduce the quantity of flow to, and the amount of water available for additional pumpage in, the southern section.

3.4.4 Water-Quality Limitations

The only water-quality data available for Lake Valley are for one well and one spring located at 9N/65E-4c and 10N/66E-31a, respectively, in the north and a well located at 3N/66E-2d in the south. Additionally, specific conductance was measured by

Rush and Eakin (1963) at several other locations. All concentrations of chemical constituents are within EPA drinking-water standards for potable water. Specific conductance measurements ranged from 31 μ-mhos/cm at North Creek Spring near Mount Grafton in the northwestern part of the valley to 2740 μ-mhos/cm at a stock watering well (7N/66E-c) near the center of the valley (Rush and Eakin, 1963). Specific conductance was generally in the range of 350 to 650 μ-mhos/cm which indicates, that on the basis of total dissolved solids, the quality of the water is generally good.

3.4.5 Potential Impacts of MX Water Resources Developent

In 1979, the Nevada State Engineer classified the northern part of Lake Valley (Lake Valley hydrographic basin) as a designated valley. Water rights for 965 acre-ft/yr (1.19 hm^3/yr) have been certified, and an additional 64,475 acre-ft/yr (79.5 hm^3/yr) are in pending applications (DRI, 1980). Therefore, additional ground-water appropriations for MX construction water may not be granted by the state engineer's office, and it may be necessary to purchase or lease water rights from current holders. In such cases, there would be no additional effects on ground water from MX development. If this is not viable, water could be imported from Spring Valley to the north or developed from possible carbonate aquifers.

Based on a driller's report that the aquifer is capable of sustaining a well yield of 2400 gpm (151 l/s) with drawdown of approximately 30 feet (9 m) and from other data, the valley-fill aquifer in Lake Valley is productive. In consideration of this and the large quantity of water in storage, with proper spacing and design of wells, there should be minimal impacts from pumping ground water for MX on the environment and water users.

In the southern section of Lake Valley, less than 1000 acre-ft/yr (1.2 hm^3/yr) have been appropriated. Because current ground-water use is minimal, additional withdrawals for MX construction needs of 2439 acre-ft/yr (3 hm^3/yr) are not expected to significantly affect local water users. However, it is possible that the increased use of water in this section of the valley might have an effect on discharge from Panaca Spring, but the consistent flow indicates that it is probably part of the deep regional carbonate aquifer and will probably not be greatly affected by drawdown in the valley-fill deposits in Lake Valley. However, to avoid potential effects, existing rights should be leased or purchased to minimize the quantity of additional ground water withdrawn from the valley-fill aquifer.

3.5 MULESHOE VALLEY

3.5.1 Physiography and Geology

Muleshoe Valley is in northern Lincoln County in east-central Nevada. The southern end of the valley is about 25 miles (40 km) northwest of Pioche. The valley is about 20 miles (32 km) long and ranges from 5 to 13 miles (8 to 21 km) wide. The basin includes 65 mi^2 (168 km^2) that are suitable for MX deployment.

The valley is bounded on the west and north by the Schell Creek Range and on the east by Dutch John Mountain, Grassy Mountain, and the Fairview Range. The southern end of the valley is separated from Dry Lake Valley by a narrow constriction of the valley-fill deposits.

Average elevations in the Schell Creek Range are about 7500 feet (2286 m). Average elevations in the Dutch John and Grassy mountains are about 8000 feet (2438 m). The Fairview Range averages about 6500 feet (1981 m). The minimum elevation in the valley is at the southern watershed boundary and is about 5200 feet (1585 m).

Muleshoe Valley is topographically and hydrologically connected to Dry Lake Valley. The land surface along the valley axis slopes about 60 ft/mi (11.4 m/km) from north to south, and both surface water and ground water discharge from Muleshoe to Dry Lake Valley. Because of the steep gradient and narrow river channel, there is no playa in Muleshoe Valley.

The Schell Creek Range is composed of volcanics of Tertiary age in the north and clastic and carbonate rocks of Paleozoic age in the south. Dutch John Mountain and Grassy Mountain are composed mainly of clastic and carbonate rocks of Paleozoic age. The Fairview Range, located along the southeastern edge of the basin, consists of volcanic rocks of Cretaceous-Tertiary age (Howard, 1978).

Four test borings were completed in the Fugro National Verification studies in FY 79. Samples from the borings showed the composition of the upper 200 feet (61 m) of the valley fill to be alluvial fan deposits of gravelly sand, fine sand, and silt with clay.

3.5.2 General Hydrology

3.5.2.1 Surface Water

There are no perennial streams in the valley, and streamflow generally occurs only in mountain ravines and over alluvial fans after high-intensity rainfall and as snowmelt runoff. Streams within the valleys and those draining mountainous terrains are generally ephemeral in nature. Runoff from the mountain streams is quickly lost to infiltration on the alluvial fans and serves to recharge the ground-water supply. The physiographic features of most of the stream channels and washes were probably formed during periods of greater precipitation (probably in Pleistocene time according to Eakin, 1963).

3.5.2.2 Ground Water

Springs in Muleshoe Valley occur in volcanic and carbonate rocks. Several spring locations in the valley were visited in FY 80 and their discharges measured. The spring discharges range from less than 1 gpm (<0.06 l/s) at 7N/64E-25dcc to 82 gpm (5.2 l/s) at 5N/65E-32ad. Because of their low discharge and low temperature, the springs are believed to be meteoric water (local precipitation and snowmelt as source).

Three springs were sampled by Fugro in FY 80 for ground-water quality data. All three samples indicated high sodium-to-calcium ratios. This additional information, plus the temperature data, indicate that deep regional aquifers are an unlikely source of recharge.

Existing well data in the study area is minimal. Only one well exists in the valley, 5N/64E-11cd, and the depth to water is greater than 290 feet (88 m). Because no direct ground-water level data are available, the potentiometric surface was inferred from indirect evidence and potentiometric data from Dry Lake Valley, Drawing B1-5. Dry Lake Valley, to the south, has a potentiometric surface at a 4800-foot (1463-m) elevation. Extrapolating the above information into Muleshoe Valley, a 5400-foot (1646-m) potentiometric surface would be expected in the northern portion of the valley, and a 5200-foot and 5000-foot (1585-m and 1524-m) potentiometric contour would be expected in the southern portion of the valley. This is considered an approximation of the potentiometric contour in Muleshoe Valley, and these data should be used accordingly. Available data are not considered adequate to evaluate recharge in Muleshoe Valley, the volume of water that migrates into Dry Lake Valley, or the perennial yield of the valley.

3.5.3 Aquifer Characteristics

Transmissivity and storage coefficient information are not available because there are no pumping wells in Muleshoe Valley. However, the relatively steep gradient of the alluvial fans combined with the moderately coarse sediments observed in Fugro National borings indicate that the transmissivity and storage coefficient values are probably at least as high as those in adjacent valleys.

3.5.4 Water-Quality Limitations

Ground-water samples for quality analyses were collected from three springs along the margin of Muleshoe Valley. Evaluations of the results of chemical analyses of the samples revealed high sodium-to-calcium ratios. This, in conjunction with the low temperatures recorded during sample collection, indicates that the springs are being recharged by meteoric water and not by the regional carbonate aquifer. Based on the water-quality criteria listed in Appendix C1.1, all of the spring locations shown in Drawing D1-5 discharge water of "good" quality for drinking purposes.

3.5.5 Potential Impacts of MX Water Resources Development

A few stock ponds that are fed by springs represent the only existing water use in Muleshoe Valley. These springs are believed to be recharged by precipitation and are not considered a part of the valley-fill aquifer. There are no permanent residents in the valley and, therefore, no ground-water extractions are being made from the valley aquifer.

The Nevada State Engineer has not estimated perennial yield for Muleshoe Valley as defined in this report. The combined ground-water system of Dry Lake Valley, Delamar Valley, and Muleshoe Valley has an estimated perennial yield of 6000 acre-ft/yr (7.4 hm^3/yr). The water required for MX construction is 4606 acre-ft/yr (5.7 hm^2/yr) total for Dry Lake and Delamar valleys for a one- or two-year period.

The additional withdrawal for MX construction of about 1079 acre-ft/yr (1.3 hm^3/yr) in Muleshoe Valley would bring the total water use to about 5685 acre-ft/yr (7.0 hm^3/yr). Because this is less than the estimated perennial yield of the Dry Lake-Delamar-Muleshoe-Valley system, these extractions are expected to have a negligible impact on the few present water users, the aquifer, and the environment within the valley. Construction in these valleys is not scheduled to occur simultaneously; MX facilities in Dry Lake Valley are currently scheduled to be constructed before those in Delamar and Muleshoe valleys. This will decrease the average yearly withdrawals from the Dry Lake-Delamar-Muleshoe Valley system.

3.6 PAHROC VALLEY

3.6.1 Physiography and Geology

Pahroc Valley is situated in central Lincoln County in southeast Nevada. The valley and surrounding mountains encompass a total area of 133 mi^2 (344 km^2) of which approximately 85 mi^2 (220 km^2) are suitable for MX siting. Pahroc Valley is approximately 15 miles (24 km) long and 10 miles (16 km) wide. The valley is bordered on the south by the Hiko and South Pahroc ranges, on the west by the Hiko Range, and on the north by the North Pahroc Range.

Pahroc Valley, as defined in this investigation, is part of the Pahranagat Hydrographic Basin. Of the total 768 mi^2 (1989 km^2) area of Pahranagat Hydrographic Basin, Pahroc Valley encompasses some 133 mi^2 (344 km^2). The valley boundaries, as studied in the MX investigation, are shown in Drawing B1-6.

Elevations of mountain crests along the east average about 7500 feet (2286 m) with the highest peak at 7948 feet (2423 m). Along the western side of the valley, the crests average about 5500 feet (1676 m) and, along the north, they average 7000 feet (2134 m). The valley floor ranges in elevation from 4000 feet (1219 m) at the southwest edge to about 5000 feet (1524 m) near the northeast border. Topographically, the valley is open and drains to Pahranagat Valley. Surface water may drain through gaps in the Hiko Range to the southwest; however, this occurrence has not been substantiated.

According to Eakin (1963), the valley-fill deposits are divided into two units, older and younger valley fill. The older unit consists mainly of unconsolidated to partly consolidated silts, sand, and gravel derived from adjacent highlands. Some volcanics are included in this unit, which ranges in age from Tertiary to Quaternary. The unit was deposited largely under subaerial and lacustrine environments and is probably between several hundred and 1000 feet (305 m) thick. The younger valley-fill unit, which is probably not more than a few tens of feet thick, consists of unconsolidated clay, silt, sand, and gravel of late Quaternary age. The valley-fill material is probably underlain by bedrock similar to that exposed in the nearby mountains.

3.6.2 General Hydrology

3.6.2.1 Surface Water

Pahroc Valley is part of in the extensive White River drainage basin which, in late Pleistocene times, was a tributary to the Virgin and Colorado rivers (Eakin, 1963). Streamflow in White

River, under present climatic conditions, occurs only from runoff during intense rain showers. Tributaries to the White River originate as mountain streams whose flow is primarily snowmelt runoff. Although no long-term streamflow data have been collected in Pahroc Valley, the valley is believed to share the seasonal characteristics of Cleve Creek in Spring Valley (Figure 3). Snowmelt runoff from the mountains begins in March or April and peaks in May and June. Low-base flow, alternating with periods of no flow, is common from August through February.

The low-base flow is sustained primarily from ground-water discharges from the mountains with runofff from infrequent, summer rain showers.

The average annual runoff from Pahroc and Pahranagat valleys has been estimated at 1800 acre-feet (2.2 hm^3) (State of Nevada, 1971). This water is primarily derived from snowmelt runoff with smaller quantities from ground-water discharge and rainfall runoff. Generally, runoff occurs in mountain streams and is lost to infiltration on the alluvial fans and recharges the ground-water system. Streamflow from Pahroc Valley reaching the White River, if any, would be from rainfall runoff following intense summer rain showers. Surface water was not observed in either the valley or in surrounding mountain drainage channels during the Fugro National field reconnaissance in FY 80.

3.6.2.2 Ground Water

At the time of this writing, information regarding the amount of recharge that occurs as a result of precipitation and runoff is not available for Pahroc Valley. Because there are virtually no phreatophytes, pumping wells, or springs in the valley area, total discharge is considered to be minimal. The one spring visited during the FY 80 field reconnaissance was dry.

As shown in the potentiometric map (Drawing B1-6), ground water appears to be moving to the southwest toward Pahranagat Valley at an average gradient of about 40 ft/mi (7.6 m/km). However, this is an extrapolation based only on the ground-surface gradient and the depth to water in two wells and is not well defined. The carbonates of Paleozoic age between the two valleys are quite capable of transmitting large quantities of water to Pahranagat Valley. This is evidenced by the combined discharge of 13,600 gpm (858 l/s) which issues from Hiko (4S/60-22), Crystal (5S/60-10), and Ash (5S/60-36) springs which are about 400 to 600 feet (122 to 183 m) lower in elevation than Pahroc Valley (Eakin, 1963).

3.6.3 Aquifer Characteristics

Because there are no operational wells in Pahroc Valley, there have been no aquifer (pump) tests performed. As a result, it is not possible to calculate transmissivity and storage coefficient values for the valley-fill or carbonate aquifers.

Well 4S/61E-28cac in Pahroc Valley has a 12-inch (30-cm) inside diameter casing that is perforated from 1200 to 1300 feet (366 to 396 m). The driller's log indicated a discharge of 200 gpm (12.6 l/s) during a 1968 pump test.

3.6.4 Water-Quality Limitations

Water-quality investigations were not conducted by the U. S. Geological Survey for Pahroc Valley, and no water was available to sample during the Fugro National field reconnaissance in FY 80. One spring in the southern part of the valley was dry as were the majority of the wells. Because some of the ground water may have been in contact with carbonate rocks, it is expected that ground water would be of the calcium- or sodium-bicarbonate type. Pahroc Spring (3S/62E-25ab), which is located in Dry Lake to the north, contains good quality water that is predominantly calcium-magnesium-sodium-bicarbonate type. Pahroc Spring was included in this section because of its close proximity to Pahroc Valley (less than 1 mile [<1.6 km] from the drainage divide).

3.6.5 Potential Impacts of MX Water Resources Development

Perennial-yield values for Pahroc Valley are not currently available. As a result, assessing the impact of 807 acre-ft/yr (1.0 hm^3/yr) of ground-water withdrawals for the construction of an MX missile cluster is not possible at this time. However, because of the size of the valley, its general characteristics, and the small quantities of water to be pumped from the valley fill, it is unlikely that the impacts from withdrawal would be significant. There are currently no operating wells in the valley. Springs along the mountain fronts are hydrologically separated from the valley fill, so withdrawals from the valley fill would not affect these springs. There could be a possible effect on spring discharge at Hiko, Crystal, and Ash springs at lower elevations in the Pahranagat Valley. However, the small possible change in the hydraulic gradient between the valley fill in Pahroc Valley and the springs in Pahranagat Valley is not expected to create a significant impact. This assumes a worst-case condition where there is hydraulic connection between the valleys.

3.7 PENOYER VALLEY

3.7.1 Physiography and Geology

Penoyer Valley, also known as Sand Springs Valley, is a north-south trending basin which encompasses 700 mi^2 (1813 km^2) in western Lincoln County, Nevada. The Worthington (Shadow) Mountains bound the valley on the east, the southern end of the study area is defined by the southerly limit of Township 2S, and the Belted Range bounds the valley on the southwest. The Quinn Canyon Range, which has the highest elevations of the study watershed, bounds the northern and northwestern end. Elevations in the watershed range from a low of about 4700 feet (1433 m) to a high of 9229 feet (2813 m) at an unnamed peak in the Quinn Canyon Range. Total relief of the basin is about 4530 feet (1380 m). Although this study has been limited to the northern portion of the valley, the hydrologic parameters, such as estimates of recharge, discharge, and perennial yield, are from Van Denburgh and Rush (1974) and are for the entire valley.

Geologic units found in Penoyer Valley are composed predominantly of carbonate rocks of Paleozoic and Mesozoic ages with minor occurrences of intrusive and extrusive igneous rocks of Tertiary age. The rocks of Paleozoic and Mesozoic age have undergone extensive structural deformation from regional tectonic forces and local granitic intrusives. The intrusive rocks throughout the area are being actively mined and explored for various minerals. Of particular note is the Union Carbide Company's Emerson Mine which mines tungsten in the nearby Timpahute Range. Additionally, exploration is currently underway in the Quinn Canyon Range.

Valley-fill deposits are predominantly coarse-grained, interfingering, alluvial sediments. There are also lenses of fine-grained or clayey deposits as noted in driller's logs of wells in the area. The intermittent occurrence of the fine-grained materials in the valley fill is due to occasional low erosion rates in the history of the basin and possible lake deposits of Pleistocene age. The valley-fill deposits are estimated to cover about 425 mi^2 (1101 km^2) or 61 percent of the total valley area.

3.7.2 General Hydrology

3.7.2.1 Surface Water

Streamflow in Penoyer Valley is derived from snowmelt runoff, ground-water discharge, and runoff from infrequent summer rainstorms. There are no perennial streams in the valley floor or the surrounding mountains. There may be some intermittent mountain streams, but the majority of the drainages are ephemeral. Streamflow that does occur is diverted for livestock watering or is rapidly lost as infiltration into the alluvial fans thereby recharging the ground-water reservoir.

Little streamflow data have been collected in Penoyer Valley due to the ephemeral nature of the streams. The average annual runoff has been estimated by indirect means to be approximately 1000 acre-ft/yr (1.2 hm^3/yr) (Van Denburgh and Rush, 1974). The majority of the surface runoff is believed to be derived from ground-water discharge (springs) from the Worthington Mountains to the east. Because the Quinn Canyon Range to the north receives its precipitation predominantly in the form of snow, runoff from this area is primarily derived from snowmelt. The seasonal runoff in Penoyer Valley is likely similar to the characteristics in Railroad Valley, with the highest runoff occurring during May and June and a much reduced flow or no flow for the remainder of the year.

3.7.2.2 Ground Water

Penoyer Valley is considered to have a closed-surface and subsurface drainage system. The partial potentiometric-surface and the two depth-to-water contours, shown in Figure B1-7, along with the known potentiometric surface contour in the southern portion of the valley indicate the hydraulic gradient is nearly horizontal in the valley-fill aquifer with the direction of flow toward a central playa. Depth to water is less than 50 feet (15 m) near the playa.

Ground-water recharge in Penoyer Valley is from precipitation, runoff, and spring discharge. Springs in the valley are located on the periphery of the valley-fill sediments except for Sand Spring at the southern end of the study area. The peripheral springs are not associated with the valley fill but are probably from perched or semiperched aquifers in the consolidated rocks.

Ground-water discharge occurs by springs, transpiration by phreatophytes, and wells for irrigation. The phreatophytes are mainly greasewood of moderate to scattered density with some saltgrass. The phreatophytes discharge an estimated 3800 acre-ft/yr (4.7 hm^3/yr). Irrigation is limited in Penoyer Valley by the availability of energy for lifting the water.

Presently, an estimated 5691 acre-ft/yr (7.0 hm^3/yr) of ground water is withdrawn annually, primarily for irrigation. Van Denburgh and Rush (1973) believed that the playa south of the study area, in Penoyer Valley, was nondischarging because the depth to water was greater than 15 feet (4.6 m). At that depth, evaporation is considered negligible.

Spring discharges in the valley measured during this reconnaissance totaled about 90 gpm (5.7 l/s). The springs which are located in the mountains are, or have been, used for livestock watering.

The transitional storage of the valley-fill aquifer in Penoyer Valley is estimated to be 770,000 acre-feet (949 hm^3) (Van Denburgh and Rush, 1974). This is based on long-range, economical use of this minable-water resource and minimum impact upon other water users.

Penoyer Valley is a designated basin for further ground-water development. The perennial yield for the valley is estimated at

5000 acre-ft/yr (6.2 hm^3/yr). Based on published data and the Fugro National reconnaissance study, the total discharge is considerably more than the perennial-yield estimates shown above. However, water levels do not indicate conclusively that mining of ground water has occurred.

Water use in the valley has undergone various increases and decreases over time. In the 1960s, the Desert Land Entry Program allowed development in the south-central portion of the valley, south of Nevada Route 375 and south of the study area boundary. Rising diesel fuel prices forced developers to abandon their land in the early seventies. There are many large irrigation wells in the valley, some which contain large-capacity pumps in working order which are not currently being used. Two farms presently growing vegetables and grains use large-capacity electric pumps.

3.7.3 Aquifer Characteristics

According to drillers' logs, existing wells penetrate relatively high transmissivity valley-fill materials. Drillers' aquifer tests of these wells indicate specific capacities ranging from 11 to 135 gpm (0.7 to 8.5 l/s) per foot of drawdown. This indicates a range in transmissivities of from about 2700 to 32,000 ft^2/day (251 to 2973 m^2/day). A short-term aquifer recovery test was performed by Fugro National in a large-capacity irrigation well about 6 miles (9.6 km) south of the study area at 3S/55E-33ccc. The results indicate transmissivities of 50,800 ft^2/day (4720 m^2/day). The location of this test is not shown in Drawing B1-7 because it lies south of the present study area. Such well yields and transmissivities indicate that the aquifer can yield sufficient quantities of ground water for MX development needs.

3.7.4 Water-Quality Limitations

Results of chemical analyses of ground water in Penoyer Valley were reviewed for potability using the criteria listed in Table C1.1. Six samples were tested for their chemical constituents by Fugro National. Results of these analyses indicate the ground water to be of generally good quality in the valley-fill aquifer. However, two mountain spring water samples were rated poor. The sample from McCutcher Spring was considered poor because of a fluoride concentration of 1.0 mg/l and Seep Springs (2S/57E-28ddb) because of a calcium concentration of 96 mg/l. Water quality deteriorates near the playa where natural salts have accumulated.

Ground-water development in the valley fill surrounding the playa should not be sufficient to reverse the ground-water gradient away from, instead of toward, the playa. However, if this occurred, the poorer quality water could permanently degrade water quality in the effected area.

3.7.5 Potential Impacts of MX Water Resources

As stated earlier, Penoyer Valley has been classified as a designated basin by the Nevada State Engineers Office. Although the estimated perennial yield is 5000 acre-ft/yr (6.2 hm^3/yr), the current use in the valley is greater than the perennial-yield estimate. Additional ground-water appropriations may not be granted, resulting in the need to purchase water rights from current holders or import water from neighboring Railroad Valley. In such cases there would be no negative effects on ground water in Penoyer Valley due to MX development water needs.

Hydrologic studies indicate that, at least in the area south of the study boundary, the aquifer is capable of sustaining well yields of over 1000 gpm (63.1 l/s). The estimated quantity of water required for MX development needs is 1623 acre-ft/yr (2.0 hm^3) for the projected two-year construction period. With proper well placement and design, well yields satisfactory for MX development could be attained with minimal impact upon current and future users and without causing migration of any suspected poor quality water from beneath playa areas toward the pumping wells.

3.8 SPRING VALLEY

3.8.1 Physiography and Geology

Spring Valley is in eastern White Pine County and northeastern Lincoln County in east-central Nevada about 20 miles (32 km) east of Ely. The valley and tributary drainage basin is approximately 120 miles (193 km) long and 15 miles (24 km) wide and has a total area of about 1700 mi^2 (4403 km^2). An area of approximately 120 mi^2 (311 km^2) in south Spring Valley is considered suitable for MX deployment.

Spring Valley is bounded on the west by the Schell Creek Range and Fortification Range and on the north by the Schell Creek Range. The eastern boundary includes the Antelope Range, Snake Range, and Kern Mountain, and the extreme southern boundary is the Wilson Creek Range. Low topographic divides separate Spring Valley from Antelope Valley to the northeast, Hamlin Valley to the southeast, and Lake Valley to the southwest. Steptoe Valley is directly west of Spring Valley across the Schell Creek Range.

Elevations within the Spring Valley watershed range from a low of 5536 feet (1687 m) to a high of 13,063 feet (3982 m) at Wheeler Peak in the Snake Range. Six other peaks in the Snake Range exceed an elevation of 11,500 feet (3505 m). Maximum elevation in the Schell Creek Range is 11,883 feet (3622 m) at North Schell Peak; seven other peaks in that range exceed an altitude of 10,000 feet (3048 m). Elevations in the Fortification and Wilson Creek ranges and Kern Mountains average about 8500 feet (2591 m) with isolated peaks in excess of 9500 feet (2896 m). The Antelope Range averages 8000 feet (2438 m) with isolated peaks in excess of 9000 feet (2743 m).

The lowest point in the valley, 5536 feet (1687 m), is on the playa east of South Schell Peak in 17N/67E. The highest points on the valley floor are at the north and south ends of the valley where the elevation is about 6500 feet (1981 m). The elevation difference between the valley floor and the surrounding peaks averages about 4000 feet (1219 m). Maximum relief occurs directly below Wheeler Peak where the elevation differential from peak to valley is in excess of 7000 feet (2134 km).

The valley is a topographically closed system. Surface runoff from the mountains drains into the valley and ultimately ponds in two playas, one in the northern part of the valley and one in the south central part.

The mountains bounding the valley are predominantly carbonate rocks of Paleozoic age on the east with lava flows and volcanic tuffs of Tertiary age on the southwest. The valley fill is divided into two major groups: older and younger alluvium. Older alluvium is of late Tertiary to Quarternary age and consists of gravel and sand formed as debris from adjacent ranges. These deposits are characteristically unconsolidated or poorly consolidated, dissected, poorly sorted, and commonly deformed (Rush and Kazmi, 1965).

Deposits of younger alluvium are undissected, unconsolidated, and relatively undisturbed. These deposits are primarily reworked sand, silt, and clay deposited by the principal streams on the valley floor and lake deposits primarily from Pleistocene time. Local drillers report Pleistocene lake deposits as deep as 300 feet (91 m) below the surface. Below the lake deposits are good sand and gravel aquifers that yield moderate to high quantities of ground water to wells (Rush and Kazmi, 1965).

3.8.2 General Hydrology

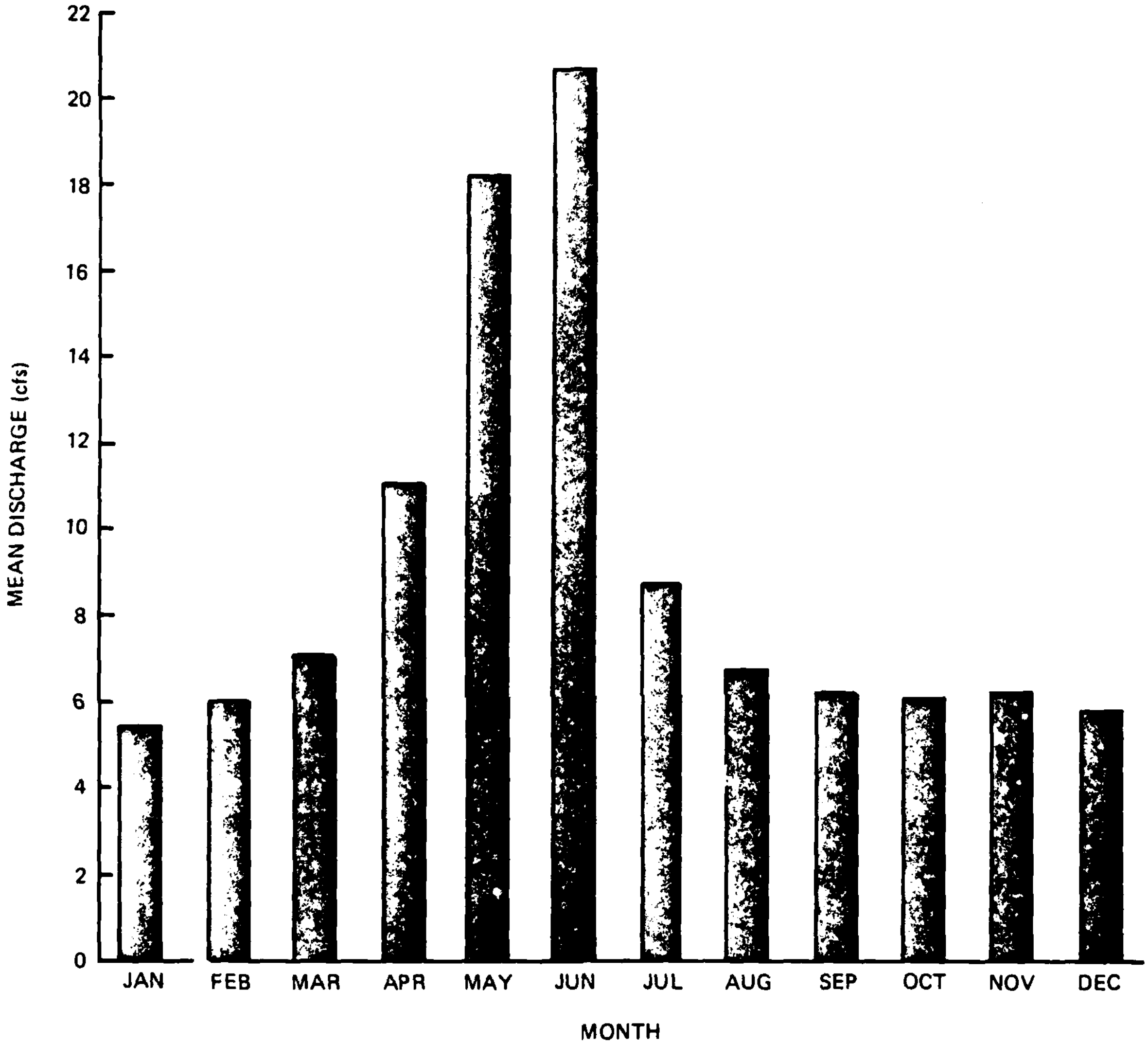
3.8.2.1 Surface Water

As previously stated, surface runoff is totally confined within Spring Valley. There are ten major streams and two major springs that drain from the surrounding mountains into the valley. The largest stream in Spring Valley is Cleve Creek which drains 20,352 acres (8326 hm^2) of the Schell Creek Range. A streamflow gauging station located near the bedrock-alluvium boundary has been intermittently operated by the U. S. Geological Survey for 12 years since 1915 in Cleve Creek. The mean monthly hydrograph for Cleve Creek (Figure 3) illustrates the seasonal runoff characteristics. Base flow exists from August through February and is primarily from ground-water sources in the mountains. Snowmelt runoff is initially noticeable in March or April, peaks in May and June, and recedes to base-flow condition by August. At present, all ten streams and both springs are diverted for irrigation and stock-water uses. About 6000 acres (2428 hm^2) are presently being irrigated with water from springs, streams, and wells (oral communication, Soil Conservation Service, 1980).

3.8.2.1 Ground Water

Drawing B1-8 shows the potentiometric-surface and depth-to-ground-water contours in the valley-fill deposits for Spring Valley. The drawing indicates that there is flow toward two playas, one in the northern part of the valley in 17N/67E and a second in the southern part of the valley in Townships 11N and 12N, Range 67E. The map is based on published water-well data and field measurements made by Fugro National during FY 80.

The potentiometric surface in Spring Valley, opposite a low divide which separates Spring Valley from Hamlin Valley, is 150 feet (46 m) higher in elevation than the potentiometric surface



AVERAGE DISCHARGE FOR 12 YEARS OF RECORD=9.01 cfs (6520 acre-ft/yr)

YEARS OF RECORD: 1915 THROUGH 1916
1960 THROUGH 1967
1977 THROUGH 1978

NOTE: ALL DATA ARE FROM U.S. GEOLOGICAL SURVEY RECORDS.
CFS = CUBIC FEET PER SECOND

DISCHARGE RECORD FOR CLEVE CREEK
SPRING VALLEY, NEVADA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - BMO

FIGURE 3

FUGRO NATIONAL, INC.

in Hamlin Valley. Also, the potentiometric gradient decreases into Hamlin Valley. This indicates that there is hydraulic connection between Hamlin and Spring valleys.

Recharge from seasonal precipitation has been estimated to be 75,000 acre-ft/yr (92.5 hm^3/yr) (Rush and Kazmi, 1965). Direct precipitation and surface runoff from the tributary watershed area infiltrate the valley fill primarily where the mountain and canyon streams contact the coarse-grained alluvial fans.

Additional recharge from ground-water inflow from Antelope Valley has been estimated to be about 2000 acre-ft/yr (2.5 hm^3/yr) (Nevada State Engineer's Office, 1971) resulting in a total volume of recharge of approximately 77,000 acre-ft/yr (94.9 hm^3/yr).

Discharge from the ground-water reservoir is from springs, wells, regional subsurface outflow, and evaporation and transpiration by phreatophytes. Six of the seven springs reported in Table F1-8 originate in carbonate rocks. The flow rate for these springs is moderate to high, and their calcium-magnesium-to-sodium ratio is also high. Evaporation and transpiration by phreatophytes is estimated to be 70,000 acre-ft/yr (86.3 hm^3/yr) (Rush and Kazmi, 1965). The evapotranspiration occurs on 186,000 acres (75,274 km^2) in Spring Valley (less then 20 percent of the total area in the valley). Indigenous phreatophytes cover 180,000 acres (72,846 km^2), and the remaining 6000 acres (2428 km^2) are covered by cultivated phreatophytes. Current ground-water withdrawal from wells is about 4828 acre-ft/yr.

Discharge from Spring Valley into Hamlin Valley by subsurface outflow is estimated to be 4000 acre-ft/yr (4.9 hm^3/yr) (Nevada State Engineer's Office, 1971). Total discharge from Spring Valley is estimated at 74,000 acre-ft/yr (91.2 hm^3/yr) (Rush and Kazmi, 1965). Perennial yield is estimated at 100,000 acre-ft/yr (123.3 hm^3/yr).

3.8.3 Aquifer Characteristics

Younger alluvium, described in the physiography and geology section, is the primary source of ground water in the valley-fill deposits of Spring Valley. These aquifers are reworked sand, silt, and clay particles deposited on the valley floor by braided streams and lakes of Pleistocene age. The lakes of Pleistocene age extended from 10N/67E to 20N/67E in Drawing B1-8. The depths of wells penetrating these deposits range from 16 feet (4.9 m) to 1040 feet (317 m). Wells are rarely drilled deeper than 400 feet (122 m), and yields of 500 gpm (31.5 1/s) are common for those wells constructed for irrigation water.

To determine the corresponding transmissivity, an aquifer test (recovery) of the valley-fill deposits was performed at 12N/67E-13dd in the valley fill along the margin of Spring Valley. The transmissivity was calculated from the data for 75-hour recovery test at about 468 ft^2/day (43.5 m^2/day). Because there were no observation wells in the vicinity, water-level recovery data were collected at the production well, and a storage coefficient could not be calculated.

3.8.4 Water-Quality Limitations

Eight wells, five streams, and two springs were sampled for water quality by Fugro National during field studies in 1980. The location of the 15 water samples and the classification of the results of analysis collected by Fugro National and nine water samples locations and analyses reported by Rush and Kazmi (1965) are shown in Drawing D1-8. The chemical analyses of all 24 samples are listed in Table C-9.

Using the water-quality criteria listed in Table C1-1, all 15 Fugro National water samples are classified as good quality. Total dissolved solids data were not available for the nine samples reported by Rush and Kazmi (1965). However, specific conductance for two of the samples reported by Rush and Kazmi (1965) were 911 and 975 mhos/cm indicating moderately high TDS locally. Based on the criteria in Table C1-1, the water quality of these samples was designated poor. Because only a few samples by Rush and Kazmi (1965) had moderately high values of specific conductance, these results are not indicative of major water-quality problems in Spring Valley.

Both springs sampled were of the calcium/magnesium-carbonate type, indicating contact with or passage through carbonate rocks. Both springs had TDS values of less than 200 mg/l which indicate good water quality and a close proximity to recharge areas.

The five streams sampled by Fugro National had TDS concentrations ranging from 3 mg/l to about 35 mg/l. The source of these streams is snowmelt from high mountain elevations.

3.8.5 Potential Impacts of MX Water Resource Development

Because the estimated yield of Spring Valley is 100,000 acre-ft/yr (123.3 hm^3/yr) and the current ground-water use is about 4781 acre-ft/yr (5.89 hm^3/yr), MX construction demands of of 1623 acre-ft/yr (2.0 hm^3/yr) can be easily accommodated. If five proposed wells each pump at a constant rate of only about 201 gpm (12.7 l/s), they will extract a total of 1623 acre-ft/yr (2.0 hm^3/yr) from the Spring Valley ground-water basin. The withdrawal program would lower the basin ground-water level at a distance of 1 mile (1.6 km) from each pumping well by only about 0.3 feet (0.09 m) at the end of a two-year construction period (assuming no recharge, average specific yield of 0.1, and transmissivity of 3500 gpd/ft [5.04 cm^2/s]). At the end of the pumping program, the water levels would return to nearly prepumped levels within a short time.

Current water use in Spring Valley is concentrated in two areas. There is extensive water use for irrigation, mining, domestic supply, and stock ponds in the southeastern part of the valley in townships 11N to 14N. Irrigation, stock ponds, and domestic supply are the main users in the west central part of the valley in townships 16N to 20N. Users in the central part of the valley heavily rely on springs for much of domestic use and pasture irrigation. MX construction wells could be located in the southern extreme of the valley to avoid possible interference effects and significant lowering of ground-water levels in existing wells or the reduction of spring discharge. To ensure minimal effects of local water users and the environment, a system of monitor stations within the valley could be established and monitored to provide early detection of changes in ground-water levels, spring discharges, and water quality due to MX ground-water withdrawals. Existing data plus the data from the monitor system would be utilized in a computer model to detect potential problems due to MX withdrawals. If changes are detected, the pumping pattern in wells in proximity to the affected area could be altered.

An alternate source of water for construction could possibly come from the lease of existing water rights of current water users for the possible one- to two-year construction period in the valley. Water obtained in this manner would not increase the quantity of existing ground-water withdrawals in the valley.

Another possible source of water supply for MX construction in Spring Valley is development of the carbonate aquifer. Testing and evaluation would be necessary to determine whether this would have a negative effect on the existing springs in the carbonate rocks and that it is an economically viable alternative.

4.0 WATER RIGHTS INVENTORY

The proposed MX siting location in the central portion of Nevada and west-central Utah is an arid region. Available supplies of surface and ground water are already largely allocated for beneficial use. Proposed major developments for mining operations and electrical generating plants will require substantial quantities of water and will compete for the available water supply with the present users. The construction of the MX system will also require significant quantities of water in each of the valley sites for a one- or two-year period.

The management and future development of water supplies in the region is generally under the jurisdiction of the respective states. To define the availability and existing appropriations in the individual siting basins, a two-phase legal study was initiated. These studies were conducted for Fugro National by the Desert Research Institute (DRI) in Nevada. The Phase I study provided an overview of the development of water law and rights as well as step-by-step water appropriation procedures for Nevada and Utah. The Phase II study summarized herein outlines existing water rights according to their legal status, water source, ownership class, and type of water use.

The Phase II study was compiled from records kept by the states engineers' offices in Nevada and Utah and was conducted between December 1979 and March 1980. The inventory was compiled for 44 hydrographic basins in Nevada and 14 hydrographic basins or areas in Utah according to the legal status of "water rights" during the period of compilation. However, only those valleys within the current area of construction consideration are listed herein.

Although terminology varies slightly between the states, for the purpose of this inventory a "water right" is divided into the following four distinct steps or circumstances involved with the legal acquisition of water:

1. An Application: may be pending further action, have been approved, have been rejected, be under protest, have been rejected and is under appeal, etc.;
2. A Permit: allows the party to proceed with an approved application under conditions prescribed with the approval;
3. A Proof: claims historical beneficial use or vested rights (Diligence Claim in Utah); and
4. A Certificate: establishes the legal status of a "water right."

A summary of water rights data for Nevada and Utah are found in Table 4, listed by hydrographic basins according to source of water and water-rights legal status. Hydrographic basins used for data compilation in the report are coincident with those defined in U. S. Geological Survey Professional Paper 813G by Eakin, Price, and Harrill (1976) and do not necessarily correspond in part or in total to the geographic valley names used in reports originated by Fugro National. An example where these area definitions vary is Dry Lake hydrographic basin which circumscribes both Dry Lake and Muleshoe valleys as defined by Fugro National.

As shown in Table 4, the aggregate ground-water and surface-water annual use represented by applications, permits, proofs,

	VALLEY	HYDROLOGIC DATA, Acre - Ft/Yr		WATER RIGHTS DATA, Acre - Ft/Yr								
				SURFACE WATER			GROUND WATER			SURFACE AND GROUND WATER		
		ESTIMATED SURFACE RUNOFF	ESTIMATED GROUND WATER PERENNIAL YIELD	PERMITS AND APPLICATIONS	CERTIFICATES AND PROOFS	TOTAL	PERMITS AND APPLICATIONS	CERTIFICATES AND PROOFS	TOTAL	PERMITS AND APPLICATIONS	CERTIFICATES AND PROOFS	TOTAL
NEVADA:	BIG SMOKY (1)	> 43,000	74,000	15,301	25,205	40,506	115,483	32,457	147,940	130,784	57,662	188,446
	KOBEH	8,000	16,000	723	— —	723	1,337	12,615	13,952	2,060	12,615	14,675
	MONITOR	67,000	18,000	11,274	10,458	21,732	30,071	226	30,297	41,345	10,684	52,029
	RALSTON	10,000	6,000	8,683	162	8,845	52,519	1,276	53,795	61,202	1,438	62,640
	STONE CABIN	9,700	2,000	1,050	518	1,568	29,620	3,897	33,517	30,670	4,415	35,085
	ANTELOPE (2)	15,000	> 4,000	52	1,519	1,571	1,356	993	2,349	1,408	2,512	3,920
	NEWARK	8,000	18,000	35	537	572	24,939	42	24,981	24,974	579	25,553
	LITTLE SMOKY (3)	> 6,000	> 6,000	831	9,871	10,702	12,802	174	12,976	13,633	10,045	23,678
	HOT CREEK (4)	8,000	6,000	18,865	1,050	19,915	25,293	3,813	29,106	44,158	4,863	49,021
	PENOYER	2,000	5,000	2,212	162	2,374	36,153	15,164	51,317	38,365	15,326	53,691
	COAL	Minor	6,000	5	184	189	6,515	— —	6,515	6,520	184	6,704
	GARDEN	8,000	6,000	29	2,144	2,173	5,760	395	6,155	5,789	2,539	8,328
	RAILROAD (4)	35,000	75,000	7,238	17,090	24,328	191,208	5,614	196,822	198,446	22,704	221,150
	STEPTOE	78,000	70,000	7,627	— —	7,627	45,923	37,073	82,996	53,550	37,073	90,623
	CAVE	10,000	2,000	— —	2,643	2,643	— —	32	32	— —	2,675	2,675
	DRY LAKE (5)	9,000 (6)	3,000	2,596	— —	2,596	361	— —	361	2,957	— —	2,957
	DELAMAR	— —	3,000	— —	250	250	— —	7	7	— —	257	257
	LAKE (7)	11,000	17,000	2,828	914	3,742	64,475	965	65,440	67,303	1,879	69,182

1. INCLUDES ALKALI SPRING FLAT WHICH IS CONSIDERED PART OF THE BIG SMOKY VALLEY SITING AREA, AND NORTHERN BIG SMOKY HYDROGRAPHIC BASIN WHICH IS NOT A SITING AREA.
2. INCLUDES STEVEN'S BASIN.
3. INCLUDES BIG SAND SPRINGS VALLEY.
4. INCLUDES PART OF REVEILLE VALLEY.
5. INCLUDES MULESHOE VALLEY. (DRYLAKE/MULESHOE)
6. INCLUDES DELAMAR VALLEY.
7. INCLUDES PATTERSON VALLEY.
8. INCLUDES PLEASANT VALLEY.
9. INCLUDES HAMLIN VALLEY.
10. HYDROGRAPHIC BASIN WHICH INCLUDES PAHROC VALLEY.
11. INCLUDED IN VALLEY ESTIMATE FOR NEVADA.
12. INCLUDES DRY LAKE SUBAREA. (SEVIER/WHIRLWIND)
13. AVERAGE OF REPORTED RANGE.

MINOR: MINOR QUANTITY, EITHER LESS THAN 500 ACRE - FEET (0.62 hm^3) PER YEAR, OR SMALL COMPARED TO OTHER QUANTITIES IN THE HYDROGRAPHIC AREA.

SUMMARY OF HYDROLOGIC AND WATER RIGHTS DATA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE — BMO

TABLE 4
1 OF 2

FUGRO NATIONAL, INC.

	VALLEY	HYDROLOGIC DATA, Acre - Ft/Yr		WATER RIGHTS DATA, Acre - Ft/Yr								
				SURFACE WATER			GROUND WATER			SURFACE AND GROUND WATER		
		ESTIMATED SURFACE RUNOFF	ESTIMATED GROUND WATER PERENNIAL YIELD	PERMITS AND APPLICATIONS	CERTIFICATES AND PROOFS	TOTAL	PERMITS AND APPLICATIONS	CERTIFICATES AND PROOFS	TOTAL	PERMITS AND APPLICATIONS	CERTIFICATES AND PROOFS	TOTAL
	SPRING	90,000	100,000	63,181	27,194	90,375	43,912	11,825	55,737	107,093	39,019	146,112
	SNAKE (8)	58,000 (9)	69,000	33,617	19,566	53,183	19,376	3,212	22,588	52,993	22,778	75,771
	HAMLIN	— —	5,000	4,346	847	5,193	181	181	362	4,527	1,028	5,555
	KANE SPRINGS	Minor	Minor	26	83	109	23,659	— —	23,659	23,685	83	23,768
	WHITE RIVER	26,000	37,000	8,061	45,126	53,187	140,772	11,128	151,900	148,833	56,254	205,087
	PAHRANAGAT (10)	< 2,000	25,000	6,876	22,114	28,990	29,722	744	30,466	36,598	22,858	59,456
UTAH	SNAKE	(11)	(11)	1,336	11,964	13,300	39,945	10,121	50,066	41,281	22,085	63,366
	PINE	N/A	7,000	2,416	8,995	11,411	17,266	221	17,487	19,682	9,216	28,898
	TULE	N/A	32,000	13	2,186	2,199	53	50	103	66	2,236	2,302
	FISH SPRINGS - FLAT	N/A	35,000	3,975	2,602	6,577	831	94	925	4,806	2,696	7,502
	DUGWAY	N/A	< 12,000	11	— —	11	384	423	807	395	423	818
	SEVIER DESERT (12)	N/A	24,600	7,903	8,469	16,372	939,993	42,442	982,435	947,896	50,911	998,807
	MILFORD	N/A	58,000	— —	30,720	30,720	— —	1,100	1,100	— —	31,820	31,820
	LUND	N/A	15,000 (13)	— —	186	186	— —	368	368	— —	554	554
	BERYL - ENTERPRISE	N/A	15,000 (13)	— —	124	124	— —	— —	— —	— —	124	124
	WAH WAH	N/A	< 10,000	903	251	1,154	32,576	34	32,610	33,479	285	33,764
	PLEASANT	(11)	(11)	— —	7,262	7,262	— —	— —	— —	— —	7,262	7,262
	HAMLIN	(11)	(11)	2,909	278	3,187	18,553	411	18,964	21,462	689	22,151
	TOTAL	> 503,700	± 781,500	214,922	260,674	475,596	1,961,038	197,097	2,148,135	2,165,960	457,771	2,623,731

1. INCLUDES ALKALI SPRING FLAT WHICH IS CONSIDERED PART OF THE BIG SMOKY VALLEY SITING AREA, AND NORTHERN BIG SMOKY HYDROGRAPHIC BASIN WHICH IS NOT A SITING AREA.
2. INCLUDES STEVEN'S BASIN.
3. INCLUDES BIG SAND SPRINGS VALLEY.
4. INCLUDES PART OF REVEILLE VALLEY.
5. INCLUDES MULESHOE VALLEY. (DRY LAKE/MULESHOE)
6. INCLUDES DELAMAR VALLEY
7. INCLUDES PATTERSON VALLEY.
8. INCLUDES PLEASANT VALLEY.
9. INCLUDES HAMLIN VALLEY.
10. HYDROGRAPHIC BASIN WHICH INCLUDES PAHROC VALLEY.
11. INCLUDED IN VALLEY ESTIMATE FOR NEVADA.
12. INCLUDES DRY LAKE SUBAREA. (SEVIER/WHIRLWIND)
13. AVERAGE OF REPORTED RANGE.

MINOR: MINOR QUANTITY, EITHER LESS THAN 500 ACRE - FEET (0.62 hm^3) PER YEAR, OR SMALL COMPARED TO OTHER QUANTITIES IN THE HYDROGRAPHIC AREA.

SUMMARY OF HYDROLOGIC AND WATER RIGHTS DATA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE — BMO

TABLE 4
2 OF 2

FUGRO NATIONAL, INC.

and certificates is about twice the estimated total of surface runoff and perennial ground-water yield in the MX siting area. If all applications and permits outstanding were to proceed to the certificate stage, and if all proofs were to be adjudicated to the claimed use, then most of the individual basins would be over-appropriated. However, this is very unlikely. In Nevada, for example, about half of the applications that have been filed since filing procedures began in 1905 have been filed within the last four or five years in conjunction with applications under the Carey and Desert Land Entry acts. As such, they are being held in a "Ready for Action" status by the Nevada State Engineer pending release of those lands from the public domain.

Surface runoff estimates presented in the table are based on precipitation and basin topography data. As such, they include all perennial, intermittent, and ephemeral streamflow. However, only intermitting streams that are supplied by base flow over a significant portion of the year and perennial flows are likely to be economically recoverable. Therefore, although estimated surface runoff exceeds the amount of total surface water applications and appropriation, recoverable surface water is nearly or totally utilized in all basins. This agrees with surface-water field reconnaissance studies performed by Fugro National. It is anticipated, therefore, that ground water will supply all MX water requirements except where it can be augmented by lease or purchase of surface-water rights and spring-discharge water rights.

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MX SITING INVESTIGATION WATER RESOURCES PROGRAM.(U)

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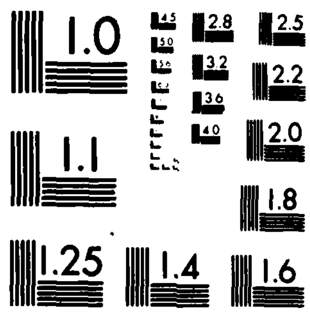
1.0
1.1
1.25
1.4
1.6
1.8
2.0
2.2
2.5
2.8
3.2
3.6
4.0

Ground-water rights data summarized in Table 4 indicate that the total amount of ground-water rights in all stages of application and appropriation exceeds the perennial yield in most basins.

As shown, the majority of these rights are in the Permits and Applications phase; certificates and proofs generally represent less than the perennial ground-water yield in each basin. These rights are not static but dynamic. On a daily basis, new applications are received; permits are issued; various proofs are filed; certificates are granted; water rights are bought, leased, or abandoned; and points and manner of diversion and use are changed.

Because of the necessary flux in the states' water-rights appropriation system, it is impossible to determine the exact status of all water rights at any given time. This is especially true with permits which allow the applicant to proceed with diversion of water. In this case, a certificate is issued after development, if the development was in accordance with the law and provisions in the permit. However, no attempt to update files as to the developmental status is made between the period a permit is granted and an application for appropriation is submitted. In general, quantities of unappropriated ground water are available in basins not "designated" by the state engineer in Nevada or "closed" to further appropriation by the Utah State Engineer. Basins are "designated" by the Nevada State Engineer when the amount of ground water appropriated nears or exceeds the perennial yield. In these areas, further appropriations will be considered based on length, amount, and type of use. In basins "closed" by the Utah State Engineer, further applications for appropriation are considered based on the same criteria.

Therefore, this inventory is valuable in determining whether and where unappropriated ground water is available, identifying potential lessors of ground water, making a preliminary evaluation of the potential for acquiring water from present users either by purchase or lease, and determining whether an effort should be made to file for a new ground-water right on available unappropriated waters. The inventory should be used in conjunction with the Industry Activity Inventories which include estimates of current water use in each basin in the evaluation of present ground-water availability. For example, as shown in the Industry Activity Inventory for Nevada ground-water, water-right certificates and proofs for the designated deployment area amount to about 158,000 acre-feet/yr (195 hm^3/yr). However, only about 148,000 acre-feet/yr (182 hm^3/yr) or 93 percent of that amount is currently being utilized.

5.0 INDUSTRY ACTIVITY INVENTORY

As previously stated in Section 4.0, available supplies of surface and ground water in the arid areas of western Utah and Nevada are already largely allocated for beneficial use. In addition to the proposed MX missile system, major developments in mining and the conversion of fossil fuels to electrical energy are proposed or currently being studied in the area. Each of these proposed developments will require substantial quantities of water and will compete for the available water supply.

An initial task in defining the availability of water for the MX missile system is to inventory all current water users in the area, determine their water demands, and estimate possible future industrial activities and their associated water requirements. An inventory of current water use along with an assessment of possible future demands within or adjacent to the Nevada-Utah siting area were initiated in the fall of 1979. The study was conducted for Fugro National by the Desert arch Institute (DRI) in Nevada and the Utah Water Research Labor. ory (UWRL) in Utah.

Water demands were evaluated in conformance with the following four major water-use categories:

1. Irrigation of cropland;
2. Livestock watering;
3. Mining and Energy - including mining, milling, power generation, and oil extraction; and

4. Urban/Industrial - including all industrial and commercial activities in urban areas.

Water use was estimated in accordance with both present and possible future requirements for each 64 valley areas within and adjacent to the Nevada-Utah siting area. However, only those valleys within the designated deployment area are listed herein.

Results of the water-use inventories are summarized in Table 5 for both the present water use within the MX siting area and potential future demands. The table shows that present ground-water use in the siting and Operational Base area is estimated to be greater than about 294,000 acre-ft/yr (363 hm^3/yr) with the largest portion of those water demands being used for irrigated agriculture (246,000 acre-ft/yr [304 hm^3/yr]). Mining- and energy-related uses represent the second largest water use, and, at present, their demands total about 40,000 acre-ft/yr (46 hm^3/yr).

Estimating future water demands within the siting area was also included as part of the water-use inventories. Mining- and energy-related water uses were found to represent the only industrial activity with the potential for substantial increases in demands for the near term. The potential exists for new mining activity as well as reviving past mining operations. New and revived mining activities and the cooling needs of possible new coal-fired electric power plants represent the chief competitors with MX for the available water. MX construction water needs, however, are of short duration. Estimated future demands for mining- and energy-related users are also shown in Table 5. Their combined future water demands total about 199,000 acre-ft/yr (245 hm^3/yr).

The potential increase in water use for mining and energy represents an increase in total water demands in the study area of 25 percent. It is somewhat problematical, however, whether or not all of these potential increases will be developed.

The study found that much of the available water supply in the area is already allocated; however, some valley areas are still capable of sustaining additional ground-water development. State regulatory agencies will assess and approve or reject each water-use proposal as it is presented. In general, energy and industrial activities are located near cities and away from planned construction locations.

Mining-related water is developed on-site in the mountains or high on alluvial fans. Agricultural development is primarily in the central valley areas. The lowering of the potentiometric surface caused by major ground-water withdrawals would have the greatest potential impact on the agricultural water users.

Although many past mining operations are currently inactive, the potential exists for reviving many of these operations as society's demand for minerals increases. The largest potential volume of water 20,000 acre-ft/yr (24.7 hm^3/yr) for a single mine operation is the Anaconda-Nevada Molybdenum Project which is presently under construction in Big Smoky Valley. There is also a potential for a total of about 16,000 acre-ft/yr

VALLEY	PRESENT GROUND - WATER USE (ACRE - FT/YR)					FUTURE (ACRE-FT/YR)
	IRRIGATION	LIVESTOCK	MINING/ ENERGY	URBAN/ INDUSTRIAL	VALLEY TOTAL	POTENTIAL MINING & ENERGY
NEVADA						
Antelope (1)	418	18	--	1	437	
Big Sand Springs	--	--	--	--	0	
Big Smoky (2)	5786	66	27,977	98	33,927	1837
Cave	--	--	--	--	0	
Coal	--	--	--	--	0	
Delamar	--	7	--	--	7	
Dry Lake (3)	--	--	--	--	0	
Garden	80	10	--	1	91	
Hamlin (4)	840	10	--	2	852	
Hot Creek (5)	190	20	81	6	297	250
Kane Springs	--	--	--	--	0	
Kobeh	3240	100	--	2	3342	
Lake (6)	13,700	30	322	114	14,166	
Little Smoky	--	--	--	--	0	
Monitor	--	--	338	--	338	5635
Newark	6435	29	40	3	6507	
Pahranagat (7)	1116	1	--	1779	2896	
Penoyer	3000	--	2687	4	5691	
Railroad (5)	1980	8	161	2057	4206	
Ralston	715	13	--	277	1005	
Snake (8)	15,199	54	484	19	15,756	27,550
Spring	2941	79	1734	27	4781	1932
Steptoe	11,057	60	871	509	12,497	34,694
Stone Cabin	939	29	--	2	970	80
White River	5260	8	--	4	5272	
UTAH						
Beryl - Enterprise (9)	77,400	750	--	370	78,520	16,530
Dugway	1400	11	--	1875	3286	
Fish Springs Flat	--	14	12	367	393	30,854
Milford (9)	47,800	300	--	1000	49,100	28,768
Pine	--	18	--	--	18	10,000
Sevier (10)	46,800	198	2258	5	49,261	33,000
Tule	--	20	--	--	20	
Wah Wah	--	2	--	--	2	8212

1. Includes Steven's Basin.
2. Includes Alkali Spring Flat which is considered part of the Big Smoky Valley Siting Area, and Northern Big Smoky Hydrographic Basin which is not a siting area.
3. Includes Muleshoe Valley (Dry Lake/Muleshoe).
4. Includes that portion of Hamlin Valley in Utah.
5. Includes part of Reveille Valley.
6. Includes Patterson Valley.
7. Hydrographic Basin which includes Pahroc Valley.
8. Includes Pleasant Valley in Nevada and that portion of Pleasant and Snake valleys in Utah.
9. From Price, Don and others, 1979, Ground - Water Conditions in Utah, Spring of 1979: Utah Dept. of Natural Resources, Cooperative Investigation Rept. No. 18, 68p.
10. Includes Dry Lake Subarea (Sevier/Whirlwind).

NOTE: Zero current annual ground-water use numbers indicate withdrawal is very minor; however, a small amount of ground-water use may occur in these valleys.

SUMMARY OF PRESENT AND PROJECTED FUTURE INDUSTRY ACTIVITIES AND WATER USE

MX SITING INVESTIGATION

DEPARTMENT OF THE AIR FORCE — BMO

TABLE 5

FUGRO NATIONAL, INC.

(19.7 hm^3/yr) from Pine Valley and Wah Wah Valley for new mining operations in those areas.

Preliminary studies are well underway for the development of major coal-fired electric power production facilities throughout the study area. In Nevada, the White Pine Power Project is a planned 1500-MW electric-power generating facility for the Ely region. A specific site has not yet been selected. Of the eight possible sites, five are within the MX siting area, with three of those classified as "most likely." The Sierra Pacific Power Company is considering three possible sites within the MX siting area, however, the potential location of those plants has not been identified. There is an "extremely low probability" that one of the Sierra Pacific sites will be selected within the next ten years. Water demands for the White Pine Power Project and the Sierra Pacific facility would total about 40,000 acre-ft/yr (49.3 hm^3/yr).

In Utah, a total of five zones are under consideration for potential coal-fired, electric-power production sites. The areas that would be impacted by these facilities are: southern Escalante Valley, Cedar Valley, Milford-Minersville Flats, Snake Valley, Fish Springs Flat, Pavant Valley, and Sevier Desert. Total water demands for these potential facilities are 203,900 acre-ft/yr (251 hm^3/yr). It should be emphasized that these are potential sites, and the final construction of all proposed facilities may never occur. Currently, the only planned facility is in the Sevier Desert at a site west of Lynndyl, north of Delta, Utah.

That project has purchased agricultural water rights, so no significant impacts are expected. Potential geothermal sites are also being investigated within the siting area.

Results of the water-use inventories indicate that there is the potential for conflicts in use of the available water resources of the area. It is possible that water supplies developed by mining or other industrial concerns could be leased by the Air Force for the short (two to three years) duration of construction in a particular ground-water basin.

APPENDIX A1.0

POTENTIOMETRIC LEVEL MEASUREMENTS

APPENDIX A

TABLE OF CONTENTS

WELL LOCATION	OWNER OR WATER USER	YEAR OF COMPLETION	DEPTH OF WELL (feet)	DIAMETER OF CASING (inches)	ELEVATION OF LAND SURFACE (feet above m.s.l.)	DATE OF MEASUREMENT (mo. - yr.)	DEPTH TO WATER (feet)	WATER LEVEL ELEVATION (feet above m.s.l.)	REFERENCES	REMARKS
9N/53E-8acd	BLM	1966	680	8	5991	6-66	630	5361	3	
8N/52E-1bd	--	--	--	12	5863	5-80	490	5373	2	
8N/52E-1bd	NRC	1968	2050	20	5863	8-68	506	5357	1*	Total Depth 6500
8N/52E-15bc	NRC	--	645	20	5910	8-68	556	<5355	1,2*	Total Depth 6011
8N/52E-25da	BLM	1966	130	--	5820	4-66	dry	<5690	3	
8N/53E/16ac	NRC	1969	720	20	5862	1-69	474	5388	1*	Total Depth 6036
7N/53E-4bbb	--	--	--	--	5790	5-80	240	5550	2	

* Several intervals in the well were tested. For shallow aquifer study, shallowest interval was chosen.

References:

1. Dinwiddie and Schroder, 1971.
2. Fugro National Measurement.
3. Nevada State Engineers Office, 1979.

NOTE: ALL ELEVATION AND DEPTH MEASUREMENTS ARE ROUNDED TO THE NEAREST FOOT, WHERE PUBLISHED DATA ARE LACKING OR INACCURATE GROUND SURFACE ELEVATIONS ARE TAKEN FROM TOPOGRAPHIC MAPS.

NEVADA LOCATIONS BASED ON MT. DIABLO BASELINE AND MERIDIAN, UTAH LOCATIONS BASED ON SALT LAKE BASELINE AND MERIDIAN.

POTENTIOMETRIC LEVEL MEASUREMENTS
BIG SAND SPRINGS VALLEY, NEVADA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE — BMO

TABLE A1-1

FUGRO NATIONAL, INC.

WELL LOCATION	OWNER OR WATER USER	YEAR OF COMPLETION	DEPTH OF WELL (feet)	DIAMETER OF CASING (inches)	ELEVATION OF LAND SURFACE (feet above m.s.l.)	DATE OF MEASUREMENT (mo. – yr.)	DEPTH TO WATER (feet)	WATER LEVEL ELEVATION (feet above m.s.l.)	REFERENCES	REMARKS
3N/60E-6cc	Fugro Nat.	1980	160	—	5100	2-80	dry	<4940	3	uncased boring
2N/59E-22b	—	—	250	—	5050	-15	dry	<4800	1	
2N/60E-3aa	Fugro Nat.	1980	118	—	5300	2-80	dry	<5182	3	uncased boring
1N/59E-4b	—	—	25	—	5000	-	dry	<4975	2	
1N/59E-22ac	Fugro Nat.	1980	162	—	4985	2-80	dry	<4823	3	uncased boring
1N/60E-33cc	Fugro Nat.	1979	190	2	5400	5-80	dry	<5210	3	cased boring
1S/59E-27ca	Fugro Nat.	1979	192	2	5000	5-80	dry	<4808	3	cased boring
2S/58E-12bb	BLM	—	188	8	5600	5-80	108	5492	2,3	
2S/60E-5cd	Panaca Farms	1965	172	16	5300	11-65	11	5289	4	

References:

1. Carpenter, 1915.
2. Eakin, 1963.
3. Fugro National Measurement.
4. Nevada State Engineers Office, 1979, unpublished drillers logs.

NOTE: ALL ELEVATION AND DEPTH MEASUREMENTS ARE ROUNDED TO THE NEAREST FOOT. WHERE PUBLISHED DATA ARE LACKING OR INACCURATE GROUND SURFACE ELEVATIONS ARE TAKEN FROM TOPOGRAPHIC MAPS.

NEVADA LOCATIONS BASED ON MT. DIABLO BASELINE AND MERIDIAN. UTAH LOCATIONS BASED ON SALT LAKE BASELINE AND MERIDIAN.

POTENTIOMETRIC LEVEL MEASUREMENTS
COAL VALLEY, NEVADA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE — BMO

TABLE A1-2

FUGRO NATIONAL, INC.

WELL LOCATION	OWNER OR WATER USER	YEAR OF COMPLETION	DEPTH OF WELL (feet)	DIAMETER OF CASING (inches)	ELEVATION OF LAND SURFACE (feet above m.s.l.)	DATE OF MEASUREMENT (mo. – yr.)	DEPTH TO WATER (feet)	WATER LEVEL ELEVATION (feet above m.s.l.)	REFERENCES	REMARKS
5N/59E-31ca	Fugro Nat.	1979	200	2	5450	5-80	115	5335	2	cased boring
5N/59E-32d	Paris	—	—	—	5350	5-80	59	5291	1,2	
4N/58E-22db	Fugro Nat.	1979	92	2	5500	5-80	dry	<5408	2	cased boring
4N/58E-23d	—	—	—	10	5350	5-80	16	5334	1,2	
4N/58E-33db	Fugro Nat.	1979	189	2	5550	5-80	dry	<5361	2	cased boring
4N/58E-36a	BLM	—	—	10	5250	5-80	25	5225	1,2	
4N/59E-6d	Wadsworth	—	—	12	5300	5-80	9	5291	1,2	
4N/59E-8b1	Wadsworth	—	—	—	5300	5-80	12	5288	1,2	
4N/59E-8b	Wadsworth	—	—	12	5300	5-80	10	5290	2	
4N/59E-30dc	Fugro Nat.	1979	100	2	5275	5-80	64	5211	2	cased boring
3N/57E-16c	Uhalde	1960	92	16	6200	5-80	19	6181	1,2,3	
3N/58E-1ad	Fugro Nat.	1979	100	2	5225	5-80	88	5137	2	cased boring
3N/58E-16a	Uhalde	1960	260	6	5300	5-80	221	5079	1,2,3	
3N/59E-18bb	Fugro Nat.	1979	200	2	5250	5-80	152	5098	2	cased boring
2N/58E-3aa	Fugro Nat.	1979	200	2	5200	5-80	139	5061	2	cased boring
2N/58E-14c	Civa Corp.	—	—	—	5150	5-80	114	5036	2	
1N/57E-20	Gold Crk. Mine	—	—	—	6200	5-80	188	6012	2	
1S/57E-2bb	Uhalde	1944	620	6	5600	6-80	489	5111	1,2,3	

References:

1. Eakin, 1963.
2. Fugro National Measurement.
3. Nevada State Engineers Office, 1979, unpublished drillers logs.

NOTE: ALL ELEVATION AND DEPTH MEASUREMENTS ARE ROUNDED TO THE NEAREST FOOT. WHERE PUBLISHED DATA ARE LACKING OR INACCURATE GROUND SURFACE ELEVATIONS ARE TAKEN FROM TOPOGRAPHIC MAPS.

NEVADA LOCATIONS BASED ON MT. DIABLO BASELINE AND MERIDIAN, UTAH LOCATIONS BASED ON SALT LAKE BASELINE AND MERIDIAN.

POTENTIOMETRIC LEVEL MEASUREMENTS
GARDEN VALLEY, NEVADA

MX SITING INVESTIGATION

DEPARTMENT OF THE AIR FORCE — BMO

TABLE A1-3

FUGRO NATIONAL, INC.

WELL LOCATION	OWNER OR WATER USER	YEAR OF COMPLETION	DEPTH OF WELL (feet)	DIAMETER OF CASING (inches)	ELEVATION OF LAND SURFACE (feet above m.s.l.)	DATE OF MEASUREMENT (mo. - yr.)	DEPTH TO WATER (feet)	WATER LEVEL ELEVATION (feet above m.s.l.)	REFERENCES	REMARKS
10N/65E-13cb	D.A. Witts	1966	130	10	6217	11-66	110	6107	2	
10N/65E-36da	Geyser Rch.	1965	843	14	5940	10-65	10	5930	2	
10N/65E-36d	Geyser Rch.	—	165	10	5970	7-63	27	5943	3	well caved in @ 28 feet
10N/66E-9a	Heckethorn	—	228	6	6040	7-63	180	5860	3	unused
10N/66E-17a	F. Twisselman	—	125	6	6010	7-63	100	5910	3	
10N/66E-31a	—	—	46	6	5935	7-63	33	5902	3	
10N/66E-31ab	D.A. Witts	1967	690	12	5940	5-67	18	5922	2	
10N/66E-31bb	Geyser Rch.	1966	468	14	5970	5-66	60	5910	2	
10N/66E-34bb	D.A. Witts	1966	155	8	6030	11-66	110	5920	2	
9N/65E-1a1	Geyser Rch.	—	165	10	5940	7-63	38	5902	3	well caved in @ 40 feet
9N/65E-1a2	Geyser Rch.	—	128	6	5980	7-63	38	5942	3	unused
9N/65E-1ba	D.A. Witts	1967	597	14	5990	1-67	25	5965	2	
9N/65E-1bd	F. Twisselman	1952	55	6	5980	11-52	38	5942	2	
9N/65E-1bd	Geyser Rch.	1961	55	6	5980	-61	35	5945	2	
9N/65E-13b	Nev. Hwy. Dept.	1962	57	6	5980	7-63	17	5963	3	
9N/65E-13ba	F. Twisselman	1950	65	6	5950	6-50	flow	>5950	2	
9N/65E-13bd	F. Twisselman	1950	52	10	5950	6-50	flow	>5950	2	
9N/65E-13cc	D.A. Witts	1967	330	14	5940	6-67	flow	>5940	2	
9N/65E-23bd	—	1967	297	10	6060	7-67	185	5875	2	
9N/65E-25cb	D.A. Witts	1967	635	16	5940	8-67	8	5932	2	
9N/65E-26aa2	Geyser Rch.	1972	100	5	5960	9-72	10	5950	2	
9N/65E-35ab	D.A. Witts	1965	580	14	5960	6-65	42	5918	2	
9N/66E-4a	—	—	53	6	5930	7-63	38	5892	3	
9N/66E-23bd	Geyser Rch.	1967	297	10	6100	7-67	185	5915	2	
9N/66E-34a	BLM	—	103	6	6000	7-63	89	5911	3	

References:
1. Fugro National Measurement.
2. Nevada State Engineers Office, 1979, unpublished drillers logs.
3. Rush, 1963.
4. Rush, 1964

NOTE: ALL ELEVATION AND DEPTH MEASUREMENTS ARE ROUNDED TO THE NEAREST FOOT. WHERE PUBLISHED DATA ARE LACKING OR INACCURATE GROUND SURFACE ELEVATIONS ARE TAKEN FROM TOPOGRAPHIC MAPS.

NEVADA LOCATIONS BASED ON MT. DIABLO BASELINE AND MERIDIAN. UTAH LOCATIONS BASED ON SALT LAKE BASELINE AND MERIDIAN.

POTENTIOMETRIC LEVEL MEASUREMENTS
LAKE VALLEY, NEVADA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE — BMO

TABLE A1-4
1 of 5

FUGRO NATIONAL, INC.

WELL LOCATION	OWNER OR WATER USER	YEAR OF COMPLETION	DEPTH OF WELL (feet)	DIAMETER OF CASING (inches)	ELEVATION OF LAND SURFACE (feet above m.s.l.)	DATE OF MEASUREMENT (mo. - yr.)	DEPTH TO WATER (feet)	WATER LEVEL ELEVATION (feet above m.s.l.)	REFERENCES	REMARKS
8N/65E-2ac	V. Mendenhall	1960	150	10	5950	5-60	35	5915	2	
8N/65E-2d	—	—	130	10	5950	7-63	36	5914	3	unused
8N/65E-10cc	Geyser Rch.	1965	383	8	6185	7-65	230	5955	2	
8N/65E-12d	BLM	—	45	4	5918	7-63	24	5894	3	
8N/65E-13	Nev. Hwy. Dept.	1957	57	8	5915	8-57	6	5909	2	
8N/65E-33d	BLM, Milk Rch.	1945	325	6	6220	8-63	298	5922	3	
8N/65E-33da	D.A. Witts	1965	390	10	6200	12-65	120	6080	2	
8N/65E-35ad	Geyser Rch.	1968	200	10	5950	1-68	55	5895	2	
8N/66E-10bc	Geyser Rch.	1968	217	8	5961	6-68	74	5887	2	
8N/66E-11bc	Fugro Nat.	1979	101	2	6080	11-79	94	5986	1	cased boring
8N/66E-27d	BLM	—	56	8	5925	7-63	45	5880	3	
8N/66E-36cb	Fugro Nat.	1979	101	2	5935	11-79	65	5870	1	cased boring
7N/65E-9 1	Geyser Rch.	1966	220	10	6220	1-67	147	6073	2	
7N/65E-9 2	Geyser Rch.	1969	410	10	6220	6-69	312	5908	2	
7N/65E-11cc	Geyser Rch.	1967	220	10	6056	6-67	147	5909	2	
7N/65E-14d	Gen. Const.	1959	300	10	5980	7-59	40	5940	2	
7N/65E-17d	BLM	—	229	6	6360	8-63	213	6147	3	
7N/65E-17da	D.A. Witts	1966	264	8	6316	6-66	200	6116	2	
7N/65E-23a	Geyser Rch.	1967	276	8	5960	12-67	75	5885	2	
7N/65E-23d	BLM	—	30	6	6020	8-63	27	5993	3	
7N/65E-35	—	1968	250	10	6320	1-68	90	6230	2	
7N/65E-6c	BLM	1942	71	6	5920	8-63	30	5890	3	
7N/66E-16dc	Fugro Nat.	1979	101	2	5920	11-79	17	5903	1	cased boring
7N/66E-33db	Geyser Rch.	1968	232	10	5932	7-68	59	5873	2	
7N/66E-36c	BLM	—	126	6	5980	7-63	110	5870	3	

References:
1. Fugro National Measurement.
2. Nevada State Engineers Office, 1979, unpublished drillers logs.
3. Rush, 1963.
4. Rush, 1964

NOTE: ALL ELEVATION AND DEPTH MEASUREMENTS ARE ROUNDED TO THE NEAREST FOOT. WHERE PUBLISHED DATA ARE LACKING OR INACCURATE GROUND SURFACE ELEVATIONS ARE TAKEN FROM TOPOGRAPHIC MAPS.

NEVADA LOCATIONS BASED ON MT. DIABLO BASELINE AND MERIDIAN. UTAH LOCATIONS BASED ON SALT LAKE BASELINE AND MERIDIAN.

POTENTIOMETRIC LEVEL MEASUREMENTS
LAKE VALLEY, NEVADA

MX SITING INVESTIGATION

DEPARTMENT OF THE AIR FORCE — BMO

TABLE A1-4
2 of 3

FUGRO NATIONAL, INC.

WELL LOCATION	OWNER OR WATER USER	YEAR OF COMPLETION	DEPTH OF WELL (feet)	DIAMETER OF CASING (inches)	ELEVATION OF LAND SURFACE (feet above m.s.l.)	DATE OF MEASUREMENT (mo. yr.)	DEPTH TO WATER (feet)	WATER LEVEL ELEVATION (feet above m.s.l.)	REFERENCES	REMARKS
7N/67E-6bb	F & M Land Co.	--	872	10	6090	2-55	32	6074	3	plugged
7N/67E-20c	--	--	180	6	6040	7-63	171	5869	3	
7N/67E-21a	BLM	--	307	6	6140	7-63	292	5848	3	
7N/67E-27ca	E. Jordan	1965	505	12	6254	10-6.	192	6062	2	
6N/65E-14da	Grassy Spg. Well	1967	152	8	6153	3-67	100	6053	2	
6N/66E-8b	BLM	1945	95	6	5931	8-63	53	5878	3	
6N/66E-10bd	L. Wiseman	1976	500	18	5945	8-76	86	5859	2	
6N/66E-19b	BLM	--	233	--	5955	8-63	97	5858	3	
6N/66E-19cb	Gen. Const.	1959	240	8	5990	6-59	90	5900	2	
6N/66E-22ba	E. Sundgren	1962	410	14	5960	6-62	101	5859	3,2	
6N/66E-22bd	A. Garwood	1962	450	14	5955	6-62	103	5852	2	
6N/66E-27ba	Geyser Rch.	1972	180	5	5955	8-72	120	5835	2	
6N/66E-27bd	J. Wright	1964	541	14	5955	11-64	102	5853	2	
6N/66E-27dd	T. Garwood	1967	476	14	5965	1-67	109	5856	2	
6N/66E-29bb	N. Larson	1967	450	14	5963	3-67	116	5847	2	
6N/66E-29bd	G. Larson	1966	421	14	5960	1-66	118	5842	2	
6N/66E-30aa	Geyser Rch.	1971	242	12	5965	11-71	135	5830	2	
6N/66E-30ab	N. Larson	1964	420	14	5980	12-64	126	5854	2	
6N/66E-30bc	Geyser Rch.	1969	320	--	6030	8-69	205	5825	2	
6N/66E-32bc	A.H. Fry	1959	175	8	6032	4-59	145	5887	2	
6N/66E-34cd	Fugro Nat.	1979	101	2	5960	11-79	94	5866	1	cased boring
6N/66E-34da	E. Sundgren	1966	500	14	5970	1-66	107	5863	2	
6N/66E-35d	BLM	--	161	8	5990	7-63	130	5860	3	
6N/67E-5b	--	1966	324	12	6040	1-66	194	5846	2	

References:
1. Fugro National Measurement.
2. Nevada State Engineers Office, 1979, unpublished drillers logs.
3. Rush, 1963.
4. Rush, 1964

NOTE: ALL ELEVATION AND DEPTH MEASUREMENTS ARE ROUNDED TO THE NEAREST FOOT. WHERE PUBLISHED DATA ARE LACKING OR INACCURATE GROUND SURFACE ELEVATIONS ARE TAKEN FROM TOPOGRAPHIC MAPS.

NEVADA LOCATIONS BASED ON MT. DIABLO BASELINE AND MERIDIAN. UTAH LOCATIONS BASED ON SALT LAKE BASELINE AND MERIDIAN.

POTENTIOMETRIC LEVEL MEASUREMENTS
LAKE VALLEY, NEVADA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE — BMO

TABLE A1-4
3 of 5

FUGRO NATIONAL, INC.

WELL LOCATION	OWNER OR WATER USER	YEAR OF COMPLETION	DEPTH OF WELL (feet)	DIAMETER OF CASING (inches)	ELEVATION OF LAND SURFACE (feet above m.s.l.)	DATE OF MEASUREMENT (mo. yr.)	DEPTH TO WATER (feet)	WATER LEVEL ELEVATION (feet above m.s.l.)	REFERENCES	REMARKS
6N/67E-18c1	BLM	1954	275	6	6080	7-63	209	5871	3	
6N/68E-9c	Atlanta Co.	--	385	12	7186	6-55	22	7164	2	
5N/66E-3ad	L. Gerlach	1966	500	14	5962	1-66	107	5855	2	
5N/66E-14ac	BLM	1955	225	6	5885	4-55	145	5740	2	
5N/66E-14b1	BLM	1955	146	6	5880	7-63	140	5740	3	
5N/66E-35	Dodge Const. Co.	1953	300	6	5940	3-53	200	5740	2	
5N/67E-35bc1	Wms. & Sons	1966	25	12	6800	12-66	3	6797	2	
5N/67E-35bc2	Wms. & Sons	1966	30	12	6800	12-66	7	6793	2	
5N/68E-6c	--	--	35	--	6640	9-63	32	6608	3	
4N/66E-2a	BLM	1937	301	6	5900	3-53	195	5705	4	
4N/66E-2cc	BLM	1937	260	7	5960	10-37	230	5730	2	
4N/66E-14	BLM	1958	303	6	5860	7-58	165	5695	2	
4N/66E-35ac	21 Mile Well	--	144	4	5775	7-63	123	5652	4	
3N/66E-2dd	BLM	1937	140	7	5730	11-37	90	5640	2	
3N/66E-8ac	Wells Cargo Inc.	1953	303	8	5900	10-53	210	5690	2	
3N/66E-22ad	Fugro Nat.	1979	--	2	5730	3-80	67	5663	1	cased boring
3N/66E-23d	15 Mile Well	1937	87	6	5676	10-63	42	5634	4	
3N/67E-4bc	BLM	1958	382	6	6000	5-78	340	5660	4,2	
3N/67E-5ad	BLM	1966	382	--	5975	12-66	352	5623	2	
2N/67E-14aa	Fugro Nat.	1979	100	2	5720	12-79	dry	<5620	1	cased boring
2N/67E-16c	K. Hollinger	1948	52	6	5600	-48	22	5578	2	
2N/67E-16d1	Eight Mile Well	--	48	6	5574	10-63	22	5552	4	
2N/67E-18bc	Fugro Nat.	1979	100	2	5800	12-79	dry	<5700	1	cased boring
2N/67E-24ba	A. Bingham	1972	190	14	5700	7-72	62	5638	2	
2N/67E-27aa	J. Tremle	1971	500	10	5533	1-71	24	5509	2	

References:
1. Fugro National Measurement.
2. Nevada State Engineers Office, 1979, unpublished drillers logs.
3. Rush, 1963.
4. Rush, 1964

NOTE: ALL ELEVATION AND DEPTH MEASUREMENTS ARE ROUNDED TO THE NEAREST FOOT. WHERE PUBLISHED DATA ARE LACKING OR INACCURATE GROUND SURFACE ELEVATIONS ARE TAKEN FROM TOPOGRAPHIC MAPS.

NEVADA LOCATIONS BASED ON MT. DIABLO BASELINE AND MERIDIAN. UTAH LOCATIONS BASED ON SALT LAKE BASELINE AND MERIDIAN.

POTENTIOMETRIC LEVEL MEASUREMENTS
LAKE VALLEY, NEVADA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE — BMO

TABLE
A1-4
4 of 5

FUGRO NATIONAL, INC.

WELL LOCATION	OWNER OR WATER USER	YEAR OF COMPLETION	DEPTH OF WELL (feet)	DIAMETER OF CASING (inches)	ELEVATION OF LAND SURFACE (feet above m.s.l.)	DATE OF MEASUREMENT (mo. - yr.)	DEPTH TO WATER (feet)	WATER LEVEL ELEVATION (feet above m.s.l.)	REFERENCES	REMARKS
2N/67E-27a	L. Kanvie	1976	89	--	5535	7-76	38	5497	2	
2N/68E-27ad	BLM	1938	40	8	5960	5-78	16	5944	4	
1N/67E-15a	Pioche Mines	1938	563	--	5760	1-38	368	5392	4	

References:
1. Fugro National Measurement.
2. Nevada State Engineers Office, 1979, unpublished drillers logs.
3. Rush, 1963.
4. Rush, 1964

NOTE: ALL ELEVATION AND DEPTH MEASUREMENTS ARE ROUNDED TO THE NEAREST FOOT. WHERE PUBLISHED DATA ARE LACKING OR INACCURATE GROUND SURFACE ELEVATIONS ARE TAKEN FROM TOPOGRAPHIC MAPS.

NEVADA LOCATIONS BASED ON MT. DIABLO BASELINE AND MERIDIAN. UTAH LOCATIONS BASED ON SALT LAKE BASELINE AND MERIDIAN.

POTENTIOMETRIC LEVEL MEASUREMENTS
LAKE VALLEY, NEVADA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE — BMO

TABLE A1-4
5 of 5

FUGRO NATIONAL, INC.

WELL LOCATION	OWNER OR WATER USER	YEAR OF COMPLETION	DEPTH OF WELL (feet)	DIAMETER OF CASING (inches)	ELEVATION OF LAND SURFACE (feet above m.s.l.)	DATE OF MEASUREMENT (mo. – yr.)	DEPTH TO WATER (feet)	WATER LEVEL ELEVATION (feet above m.s.l.)	REFERENCES	REMARKS
5N/64E-11cdb	—	—	>290	—	5680	5-80	dry	<5390	1	Malloy Well

References:

1. Fugro National Measurement

NOTE: ALL ELEVATION AND DEPTH MEASUREMENTS ARE ROUNDED TO THE NEAREST FOOT. WHERE PUBLISHED DATA ARE LACKING OR INACCURATE GROUND SURFACE ELEVATIONS ARE TAKEN FROM TOPOGRAPHIC MAPS.

NEVADA LOCATIONS BASED ON MT. DIABLO BASELINE AND MERIDIAN. UTAH LOCATIONS BASED ON SALT LAKE BASELINE AND MERIDIAN.

POTENTIOMETRIC LEVEL MEASUREMENTS
MULESHOE VALLEY, NEVADA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE — BMO

TABLE A1-5

FUGRO NATIONAL, INC.

WELL LOCATION	OWNER OR WATER USER	YEAR OF COMPLETION	DEPTH OF WELL (feet)	DIAMETER OF CASING (inches)	ELEVATION OF LAND SURFACE (feet above m.s.l.)	DATE OF MEASUREMENT (mo. - yr.)	DEPTH TO WATER (feet)	WATER LEVEL ELEVATION (feet above m.s.l.)	REFERENCES	REMARKS
3S/61E-34bb	—	—	>500	12	4713	6-80	>500	<4213	2	
4S/61E-1aa	—	—	>500	8	4520	6-80	>500	<4020	2	
4S/61E-9ac	Seventy Corp.	1965	300	—	4460	10-65	dry	<4160	3	no casing
4S/61E-15db	—	—	—	6	4375	2-77	670	3705	1,4	sealed off @ 50 feet
4S/61E-22ca	C.J. Stewart	1963	310	—	4300	12-63	dry	<3990	3	no casing
4S/61E-23ad	Doug Stewart	1963	160	—	4470	12-63	dry	<4310	3	no casing
4S/61E-28cac	E.M. Nagel	1968	1314	18	4230	9-68	595	3635	3	
4S/62E-7dd	—	—	104	4	4640	6-80	dry	<4536	2	
4S/62E-9dd2	Seventy Corp.	1965	410	—	4900	10-65	dry	<4490	3	no casing
4S/62E-9dd3	Seventy Corp.	1965	240	—	4920	10-65	dry	<4680	3	no casing
5S/61E-9bd	Chamberlain	1967	25	10	4410	6-80	dry	<4385	2	
5S/61E-16bd	Schwartz	1967	10	10	4425	6-80	dry	<4415	2	

References:

1. Eakin, 1963.
2. Fugro National Measurement.
3. Nevada State Engineers Office, 1979, unpublished drillers logs.
4. U. S. Geological Survey, 1980, unpublished computer printout.

NOTE: ALL ELEVATION AND DEPTH MEASUREMENTS ARE ROUNDED TO THE NEAREST FOOT. WHERE PUBLISHED DATA ARE LACKING OR INACCURATE GROUND SURFACE ELEVATIONS ARE TAKEN FROM TOPOGRAPHIC MAPS.

NEVADA LOCATIONS BASED ON MT. DIABLO BASELINE AND MERIDIAN. UTAH LOCATIONS BASED ON SALT LAKE BASELINE AND MERIDIAN.

POTENTIOMETRIC LEVEL MEASUREMENTS
PAHROC VALLEY, NEVADA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE — BMO

TABLE A1-6

FUGRO NATIONAL, INC.

WELL LOCATION	OWNER OR WATER USER	YEAR OF COMPLETION	DEPTH OF WELL (feet)	DIAMETER OF CASING (inches)	ELEVATION OF LAND SURFACE (feet above m.s.l.)	DATE OF MEASUREMENT (mo. – yr.)	DEPTH TO WATER (feet)	WATER LEVEL ELEVATION (feet above m.s.l.)	REFERENCES	REMARKS
1S/55E-18dd	Fugro Nat.	1979	188	2	5250	3-80	dry	<5062	1	Cased Boring
1S/55E-22abd	--	—	—	—	5050	6-80	288	4762	1	
1S/56E-28bd	Fugro Nat.	1979	192	2	5401	1-80	dry	<5209	1	Cased Boring
2S/55E-20abb	—	—	—	—	4956	6-80	250	4706	1	
2S/55E-24cd	Fugro Nat.	1979	160	2	4785	3-80	55	4730	1	Cased Boring
2S/56E-10ab	—	—	--	6	4730	6-80	96	4634	1	
2S/56E-32ad	Fugro Nat.	1979	200	2	4860	3-80	125	4735	1	Cased Boring

References:

1. Fugro National Measurement.

NOTE: ALL ELEVATION AND DEPTH MEASUREMENTS ARE ROUNDED TO THE NEAREST FOOT. WHERE PUBLISHED DATA ARE LACKING OR INACCURATE GROUND SURFACE ELEVATIONS ARE TAKEN FROM TOPOGRAPHIC MAPS.

NEVADA LOCATIONS BASED ON MT. DIABLO BASELINE AND MERIDIAN. UTAH LOCATIONS BASED ON SALT LAKE BASELINE AND MERIDIAN.

POTENTIOMETRIC LEVEL MEASUREMENTS
PENOYER VALLEY, NEVADA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE – BMO

TABLE A1-7

FUGRO NATIONAL, INC.

WELL LOCATION	OWNER OR WATER USER	YEAR OF COMPLETION	DEPTH OF WELL (feet)	DIAMETER OF CASING (inches)	ELEVATION OF LAND SURFACE (feet above m.s.l.)	DATE OF MEASUREMENT (mo. - yr.)	DEPTH TO WATER (feet)	WATER LEVEL ELEVATION (feet above m.s.l.)	REFERENCES	REMARKS
24N/66E-31cb	BLM	1966	211	6	6630	9-66	140	6490	2	
23N/65E-10d1	—	—	—	80	6685	4-60	65	6620	3	
23N/65E-14c1	—	—	140	—	6660	—	124	6536	3	
23N/66E-7c1	E.A. Henroid	—	23	36	6780	8-49	16	6464	3	
23N/66E-19a1	L. Henroid	—	30	6	6400	8-49	20	6380	3	
23N/66E-31a1	L. Henroid	—	600	6	6380	8-49	flow	>6380	3	
23N/66E-31a2	L. Henroid	1945	49	8	6380	8-49	17	6363	3	
23N/66E-31b1	L. Henroid	—	49	8	6370	8-49	16	6354	3	
23N/66E-31b2	H.L. Anderson	1923	1040	8	6370	8-49	flow	>6370	3	
23N/66E-31c1	L. Henroid	1953	104	16	6370	6-53	26	6344	2,3	
21N/66E-4b1	Doutre Ranch	—	—	6	6070	7-64	21	6049	3	
20N/66E-13ab	D. Eldridge	1966	305	16	5770	6-80	125	5645	1,2	
20N/67E-8d1	—	—	280	—	5780	4-60	182	5598	3	
20N/67E-25bd	—	—	—	—	5720	6-80	144	5576	1	
20N/67E-26a1	Eldridge Rch		130	4	5700	6-50	100	5600	3	
20N/67E-26a2	Eldridge Rch	—	123	20	5700	7-64	121	5579	3	
19N/66E-11b1	R. Robinson	—	400	—	5700	4-60	41	5659	3	
19N/67E-13aa	—	—	53	8	5630	6-80	49	5581	1,3	
19N/66E-14ab	R. Robinson	1972	815	16	5620	9-72	50	5580	2	
18N/66E-1b	R. Bates	1953	68	6	5600	7-53	20	5580	2,3	
18N/66E-2a1	—	—	60	—	5760	10-62	31	5661	3	
18N/66E-25a1	B. Robinson	1948	98	6	5600	11-48	60	5540	2,3	
18N/67E-1c1	R. Bates	—		38	5570	7-64	59	5511	3	
18N/68E-31a1	Eldridge	1947	465	6	5580	3-61	58	5522	2,3	

References:

1. Fugro National Measurement
2. Nevada State Engineers Office, 1979, unpublished drillers logs.
3. Rush and Kazmi, 1965.
4. U. S. Geological Survey, 1980, oral communication.

NOTE: ALL ELEVATION AND DEPTH MEASUREMENTS ARE ROUNDED TO THE NEAREST FOOT. WHERE PUBLISHED DATA ARE LACKING OR INACCURATE GROUND SURFACE ELEVATIONS ARE TAKEN FROM TOPOGRAPHIC MAPS.

NEVADA LOCATIONS BASED ON MT. DIABLO BASELINE AND MERIDIAN. UTAH LOCATIONS BASED ON SALT LAKE BASELINE AND MERIDIAN.

POTENTIOMETRIC LEVEL MEASUREMENTS
SPRING VALLEY, NEVADA

MX SITING INVESTIGATION

DEPARTMENT OF THE AIR FORCE — BMO

TABLE A1-8
1 of 5

FUGRO NATIONAL, INC.

WELL LOCATION	OWNER OR WATER USER	YEAR OF COMPLETION	DEPTH OF WELL (feet)	DIAMETER OF CASING (inches)	ELEVATION OF LAND SURFACE (feet above m.s.l.)	DATE OF MEASUREMENT (mo. - yr.)	DEPTH TO WATER (feet)	WATER LEVEL ELEVATION (feet above m.s.l.)	REFERENCES	REMARKS
18N/68E-31a2	Eldridge	—	80	5	5580	8-49	45	5535	3	
17N/67E-8bc	H. Yelland	—	—	—	5570	6-80	flow	>5570	1	
17N/67E-28a1	BLM/Rogers	1935	29	38	5560	6-80	0	5560	1,3	
17N/67E-30cb	Peterson	1972	100	—	5690	8-72	flow	>5690	2	
17N/68E-6a1	BLM/Eldridge	—	31	38	5570	8-49	24	5546	3	
17N/68E-6d1	B. Robinson	1951	500	16	5570	11-64	29	5541	2,3	
17N/68E-7a1	BLM/Eldridge	1935	31	38	5560	7-64	28	5532	3	
16N/66E-26a	BLM	1964	260	6	5950	12-64	230	5720	2	
16N/67E-3a1	H.T. Rogers	—	16	—	5580	8-49	3	5577	3	no casing
16N/67E-3a2	Rogers Bros.	1950	317		5580	6-80	4	5576	1,2	
16N/67E-4db	BLM	1970	160	6	5590	2-70	flow	>5590	2	
16N/67E-11ab	R. Lahm	1973	150	9	5635	5-73	35	5600	2	
16N/67E-18a1	J. Chachas	—	16	48	5580	6-80	3	5577	1,2	
16N/67E-27d1	BLM/Yelland	—	16	38	5630	6-80	10	5620	1	
15N/66E-24b1	Bastian Rch	—	82	6	5830	11-64	20	5810	3	
15N/67E-7c	R. Lewis	1975	135	9	5760	1-75	40	5720	2	test well
15N/67E-19ba	Bastian Rch	1947	83	16	5700	6-80	7	5694	1,2	
15N/67E-26cd	—	—	—	—	5685	6-80	flow	>5685	1	abandoned
14N/66E-24a1	BLM	—	27	36	5820	6-80	25	5795	3	
14N/66E-25b1	—	—	61	24	5820	8-44	24	5796	3	
14N/66E-34cd	Dept of Highways	1968	452	10	6160	6-80	338	5823	1,2	
14N/67E-7d1	Experimental Farms	1935	340	8	5800	11-44	flow	5800	3	
14N/67E-15db	Clark Mining	1977	294	8	5949	6-77	250	5699	2	
14N/67E-15c1	—	—	600	14	5780	4-60	12	5768	3	
14N/67E-16dd	Space Metals	1970	200	14	5770	9-70	30	5740	2	

References:

1. Fugro National Measurement.
2. Nevada State Engineers Office, 1979, unpublished drillers logs.
3. Rush and Kazmi, 1965.
4. U. S. Geological Survey, 1980, oral communication.

NOTE: ALL ELEVATION AND DEPTH MEASUREMENTS ARE ROUNDED TO THE NEAREST FOOT. WHERE PUBLISHED DATA ARE LACKING OR INACCURATE GROUND SURFACE ELEVATIONS ARE TAKEN FROM TOPOGRAPHIC MAPS.

NEVADA LOCATIONS BASED ON MT. DIABLO BASELINE AND MERIDIAN. UTAH LOCATIONS BASED ON SALT LAKE BASELINE AND MERIDIAN.

POTENTIOMETRIC LEVEL MEASUREMENTS
SPRING VALLEY, NEVADA

MX SITING INVESTIGATION

DEPARTMENT OF THE AIR FORCE — BMO

TABLE A1-8

2 of 5

FUGRO NATIONAL, INC.

WELL LOCATION	OWNER OR WATER USER	YEAR OF COMPLETION	DEPTH OF WELL (feet)	DIAMETER OF CASING (inches)	ELEVATION OF LAND SURFACE (feet above m.s.l.)	DATE OF MEASUREMENT (mo. - yr.)	DEPTH TO WATER (feet)	WATER LEVEL ELEVATION (feet above m.s.l.)	REFERENCES	REMARKS
14N/67E-21dc	Comstock Six Placer	1964	154	—	5750	5–68	33	5727	2	
14N/67E-22cc	Frandsen	1969	238	16	5820	8–69	64	5756	2	
14N/67E-27bc	S.P. Valley Gold drilling	1974	193	16	5860	2–74	140	5620	2	
13N/66E-5a1	Buzz Pierce	1955	45	6	6490	10–55	15	6475	3	
13N/66E-25a1	BLM	1951	120	6	5950	1–51	60	5890	3	
13N/67E-8a1	Swallow Well	1936	45	38	5780	6–80	14	5766	1,3	USGS Observation Well
13N/67E-15d1	M. Robinson	1948	290	16	5950	11–64	73	5877	2,3	
13N/67E-15d2	M. Robinson	—	300	6	5900	8–49	60	5840	3	
13N/67E-16dc	R. Harbecke	1972	272	—	5925	7–71	72	5753	2	
13N/67E-17d1	R. Harbecke	1971	120	—	5795	4–60	53	5742	3	
13N/67E-22a1	—	—	—	—	5870	4–60	70	5800	3	
13N/67E-22ad	Rasmassen	1972	300	8	5860	2–72	60	5800	2	
13N/67E-22ba	R. Harbecke	1968	550	10	5852	1–68	58	5793	2	
13N/67E-22d1	Yelland	1949	63	6	5830	8–49	25	5805	2,3	
13N/67E-26bb	R.B. Swallow	1972	100	6	5845	6–80	65	5780	1,2	
13N/67E-26bd	J.L. Larson	1964	335	14	5818	12–61	65	5790	2	
13N/67E-26dc	D. Eldridge	1967	300	—	5850	6–67	48	5802	2	
13N/67E-31d2	Doyle Well	—	—	—	5788	4–60	23	5765	3	
13N/67E-33d1	—	1949	456	16	5775	6–80	6	5770	1,3	
13N/67E-34aa	J.L. Larson	1966	915	3	5780	7–66	14	5786	2	
3N/67E-35c1	BLM	—	—	6	5800	8–49	flow	>5800	3	
13N/67E-35d1	BLM	—	396	6	5830	8–49	flow	5836	3	head is 6 feet above land surface
12N/66E-21cd	BLM	1966	631	8	6365	9–66	564	5801	2	
12N/66E-26	BLM	1967	650	—	5980	1–67	590	5390	2	

References:

1. Fugro National Measurement.
2. Nevada State Engineers Office, 1979, unpublished drillers logs.
3. Rush and Kazmi, 1965.
4. U. S. Geological Survey, 1980, oral communication.

NOTE: ALL ELEVATION AND DEPTH MEASUREMENTS ARE ROUNDED TO THE NEAREST FOOT. WHERE PUBLISHED DATA ARE LACKING OR INACCURATE GROUND SURFACE ELEVATIONS ARE TAKEN FROM TOPOGRAPHIC MAPS.

NEVADA LOCATIONS BASED ON MT. DIABLO BASELINE AND MERIDIAN. UTAH LOCATIONS BASED ON SALT LAKE BASELINE AND MERIDIAN.

POTENTIOMETRIC LEVEL MEASUREMENTS
SPRING VALLEY, NEVADA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE — BMO

TABLE A1-8
3 of 5

FUGRO NATIONAL, INC.

WELL LOCATION	OWNER OR WATER USER	YEAR OF COMPLETION	DEPTH OF WELL (feet)	DIAMETER OF CASING (inches)	ELEVATION OF LAND SURFACE (feet above m.s.l.)	DATE OF MEASUREMENT (mo.-yr.)	DEPTH TO WATER (feet)	WATER LEVEL ELEVATION (feet above m.s.l.)	REFERENCES	REMARKS
12N/67E-2a1	BLM	1935	407	6	5800	6-30	flow	>5800	1,3	
12N/67E-2a2	Fish and Game	1949	194	6	5800	3-50	flow	>5800	2,3	
12N/67E-2a3	BLM	1935	750	8	5800	3-50	flow	>5800	3	
12N/67E-2a4	BLM	—	283	6	5800	3-50	flow	>5800	3	
12N/67E-3b1	—	1935	30	60	5770	8-53	8	5762	3	USGS Observation Well
12N/67E-8a1	—	1938	45	38	5750	1935	20	5730	3	
12N/67E-11a1	D. Yelton	—	21	36	5800	8-49	12	5788	3	
12N/67E-11a2	D. Yelton	—	10	24	5800	8-49	6	5794	3	
12N/67E-12ac	Bransford	1976	190	13	5920	6-80	31	5889	1,2	
12N/67E-12d1	Kirkeby	—	300	6	5920	8-49	14	5906	3	
12N/67E-12d2	Kirkeby	—	21	48	5920	8-49	14	5906	3	
12N/67E-12d3	Kirkeby	1959	185	—	5940	7-59	50	5890	2,3	
12N/67E-13a1	Kirkeby	1955	80	6	5850	10-55	8	5842	2,3	
12N/67E-13b1	Kirkeby	1959	220	6	5820	7-59	flow	5820	2,3	
12N/67E-13dd	R.B. Swallow	1970	204	16	5890	6-80	44	5847	2	
12N/67E-24b1	Kirkeby	1959	155	8	5800	7-59	flow	>5800	3	
12N/67E-24cd	R.B. Swallow	—	300	—	5850	6-80	26	5824	1,2	
12N/67E-26aa	R.B. Swallow	1960	14	—	5780	6-80	19	5761	1,2	
12N/67E-27b1	A. Kirkeby	1955	30	—	5751	10-55	13	5738	2,3	
12N/67E-31dd	E. Rhodes	1964	456	16	5755	4-64	15	5740	2	
11N/66E-1ab	E. Rhodes	1964	—	16	5780	6-80	flow	>5780	1,2	
11N/66E-23ab	Fugro Nat.	1979	101	2	5830	6-80	49	5781	1	FNI Test Boring
11N/66E-24a1	—	—	28	42	5770	6-80	19	5752	1,3	
11N/66E-24d	—	—	28	—	5765	6-80	19	5746	1	
11N/66E-35db	D. Heckethorne	1959	240	6	5784	6-30	flow	>5784	1,2	abandoned

References:

1. Fugro National Measurement.
2. Nevada State Engineers Office, 1979, unpublished drillers logs.
3. Rush and Kazmi, 1965.
4. U. S. Geological Survey, 1980, oral communication.

NOTE: ALL ELEVATION AND DEPTH MEASUREMENTS ARE ROUNDED TO THE NEAREST FOOT. WHERE PUBLISHED DATA ARE LACKING OR INACCURATE GROUND SURFACE ELEVATIONS ARE TAKEN FROM TOPOGRAPHIC MAPS.

NEVADA LOCATIONS BASED ON MT. DIABLO BASELINE AND MERIDIAN. UTAH LOCATIONS BASED ON SALT LAKE BASELINE AND MERIDIAN.

POTENTIOMETRIC LEVEL MEASUREMENTS
SPRING VALLEY, NEVADA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE — BMO

TABLE A1-8
4 of 5

FUGRO NATIONAL, INC.

WELL LOCATION	OWNER OR WATER USER	YEAR OF COMPLETION	DEPTH OF WELL (feet)	DIAMETER OF CASING (inches)	ELEVATION OF LAND SURFACE (feet above m.s.l.)	DATE OF MEASUREMENT (mo. – yr.)	DEPTH TO WATER (feet)	WATER LEVEL ELEVATION (feet above m.s.l.)	REFERENCES	REMARKS
11N/67E-1bc	Swallow Bros	—	54	4	5790	6-80	flow	>5790	1,3	
11N/67E-1c	—	—	—	-	5820	6-80	flow	>5820	1	
11N/67E-1c1	Swallow Bros	—	55	4	5820	3-50	flow	>5820	3	
11N/67E-13b1	BLM	1935	15	38	5800	1935	7	5793	3	
11N/67E-13dc	Swallow	1964	450	14	5780	9-64	10	5770	2	
11N/68E-29ba	C.M. Reduc. Co.	1935	353	8	6110	11-53	250	5860	3	
11N/68E-31c1	BLM-Swallow	1935	80	38	5870	7-64	71	5799	3	
10N/67E-16a1	BLM	—	54	38	5840	—	45	5798	3	dug well
10N/67E-26bb	Fugro Nat.	1979	100	2	5905	6-80	66	5839	1	FNI Test Boring
10N/68E-29cc	—	—	—	—	5930	6-80	157	5773	1	John's Wash Well
10N/68E-36da	Geyser Rch	1965	468	14	6500	5-65	60	6440	2	
9N/68E-21dc	Fugro Nat.	1979	101	2	5970	6-80	dry	<5869	1	FNI Test Boring
8N/68E-15bd	BLM	—	495	6	6180	6-80	408	5772	1,2	

References:

1. Fugro National Measurement.
2. Nevada State Engineers Office, 1979 , unpublished drillers logs.
3. Rush and Kazmi, 1965.
4. U. S. Geological Survey, 1980, oral communication.

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NEVADA LOCATIONS BASED ON MT. DIABLO BASELINE AND MERIDIAN. UTAH LOCATIONS BASED ON SALT LAKE BASELINE AND MERIDIAN.

POTENTIOMETRIC LEVEL MEASUREMENTS
SPRING VALLEY, NEVADA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE — BMO

TABLE A1-8
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FUGRO NATIONAL, INC.

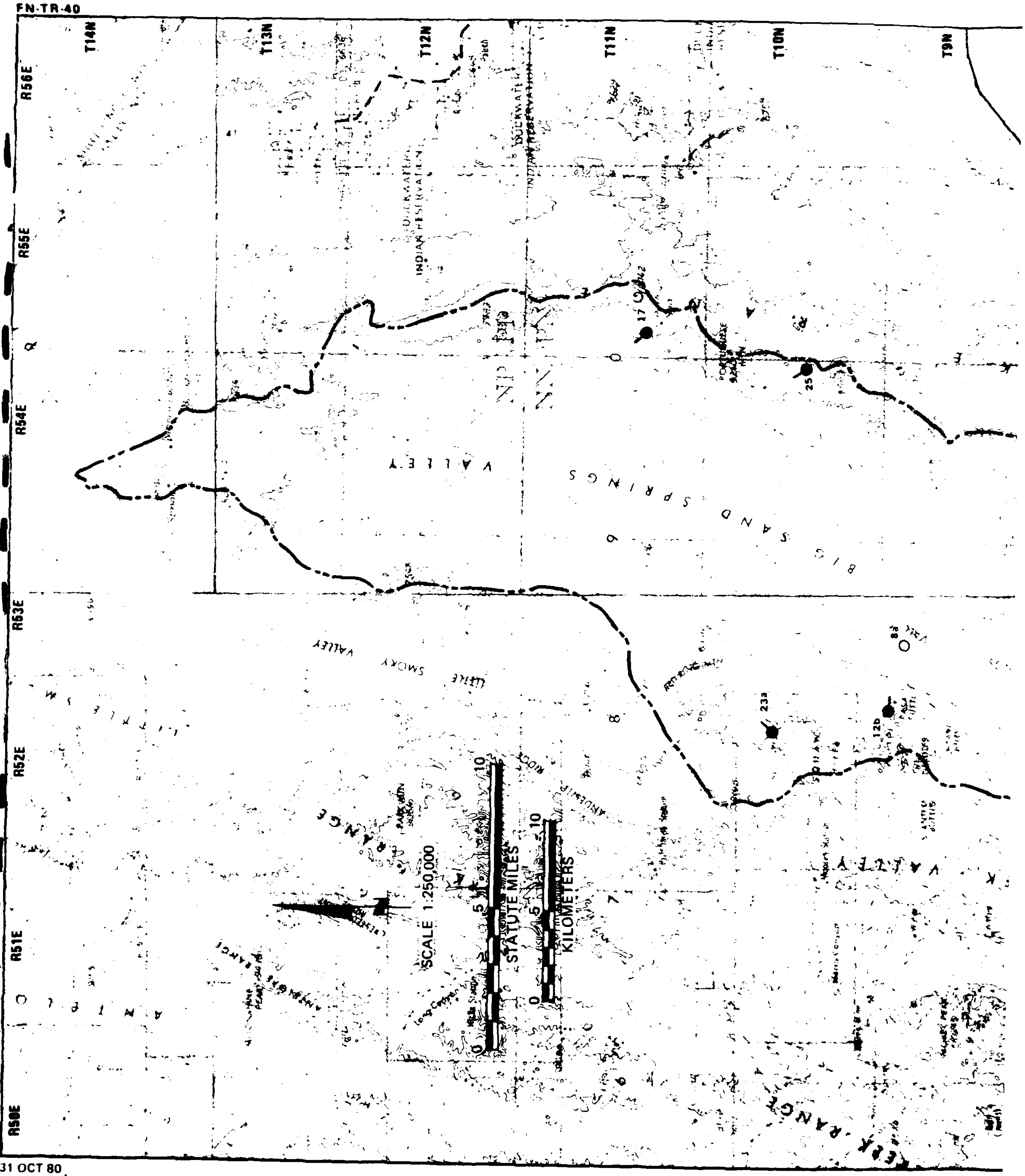
APPENDIX B1.0

POTENTIOMETRIC LEVEL DRAWINGS

APPENDIX B

TABLE OF CONTENTS

B1.0 POTENTIOMETRIC LEVEL DRAWINGS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R55E
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R51E
R50E
DUCKWATER INDIAN RESERVATION
VALLEY
BIG SAND SPRINGS
LITTLE SMOKY VALLEY
RANGE
SCALE 1:250,000
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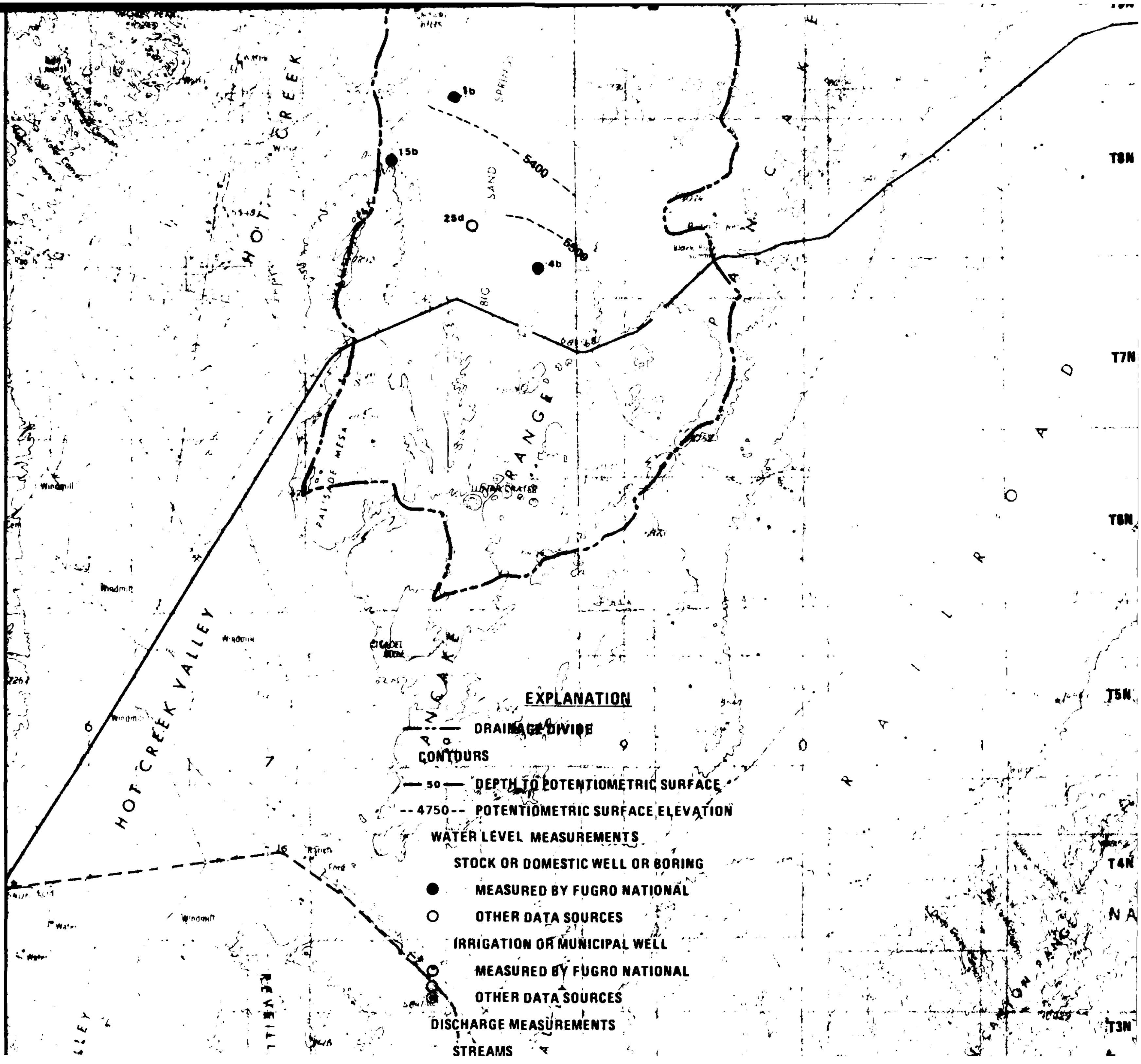
STATUTE MILES
0 5 10
KILOMETERS
17
25
23a
12b



EXPLANATION
DRAINAGE DIVIDE
CONTOURS
50 DEPTH TO POTENTIOMETRIC SURFACE
4750 POTENTIOMETRIC SURFACE ELEVATION
WATER LEVEL MEASUREMENTS
STOCK OR DOMESTIC WELL OR BORING
MEASURED BY FUGRO NATIONAL
OTHER DATA SOURCES
IRRIGATION OR MUNICIPAL WELL
MEASURED BY FUGRO NATIONAL
OTHER DATA SOURCES
DISCHARGE MEASUREMENTS
STREAMS
HOT CREEK VALLEY
HOT CREEK
RANGE
PALISADE MESA
BIG SAND SPRINGS
RAILROAD
5400
5300
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15b
25d
4b
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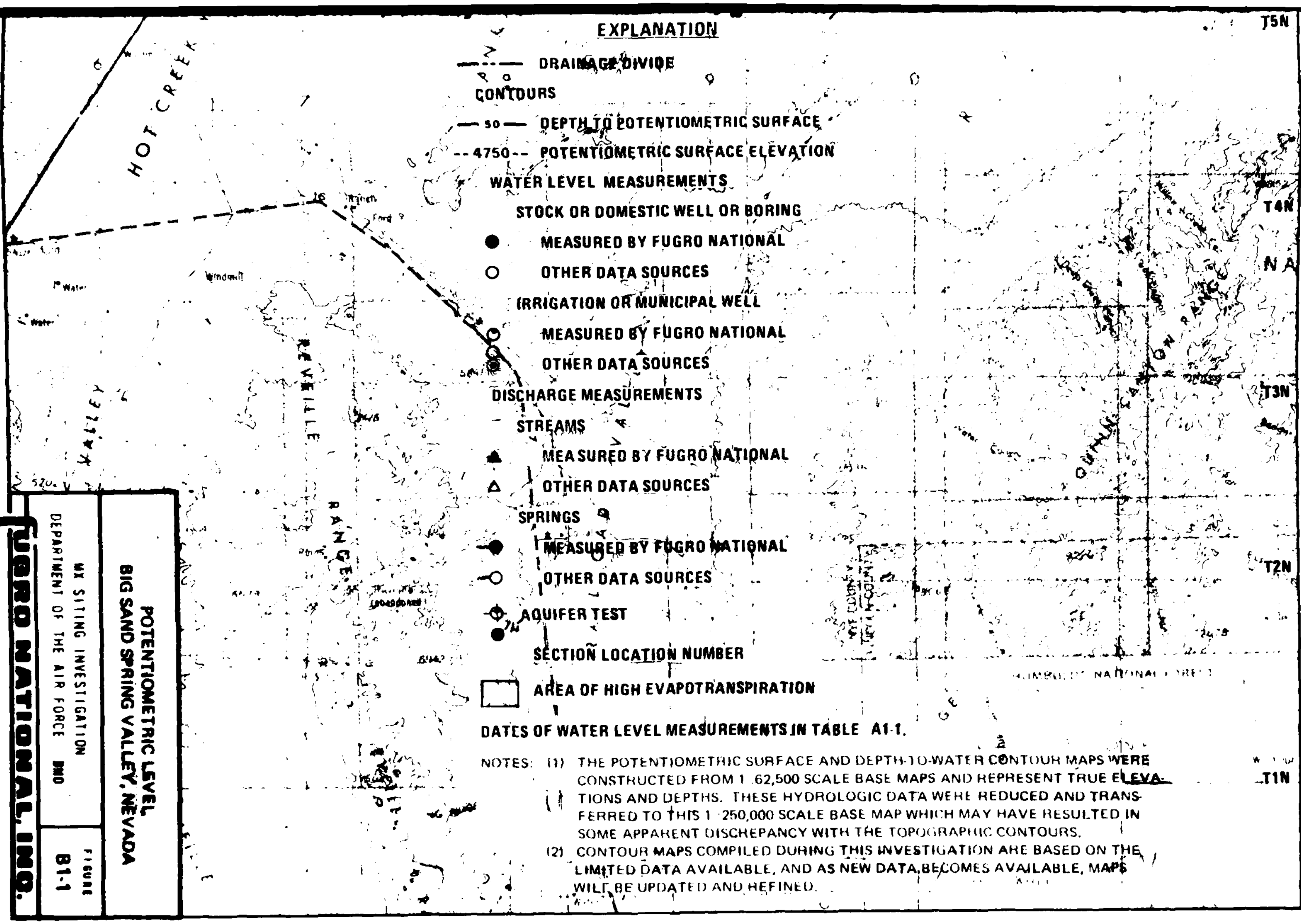
T7N
T6N
T5N
T4N
T3N
Windmill

2



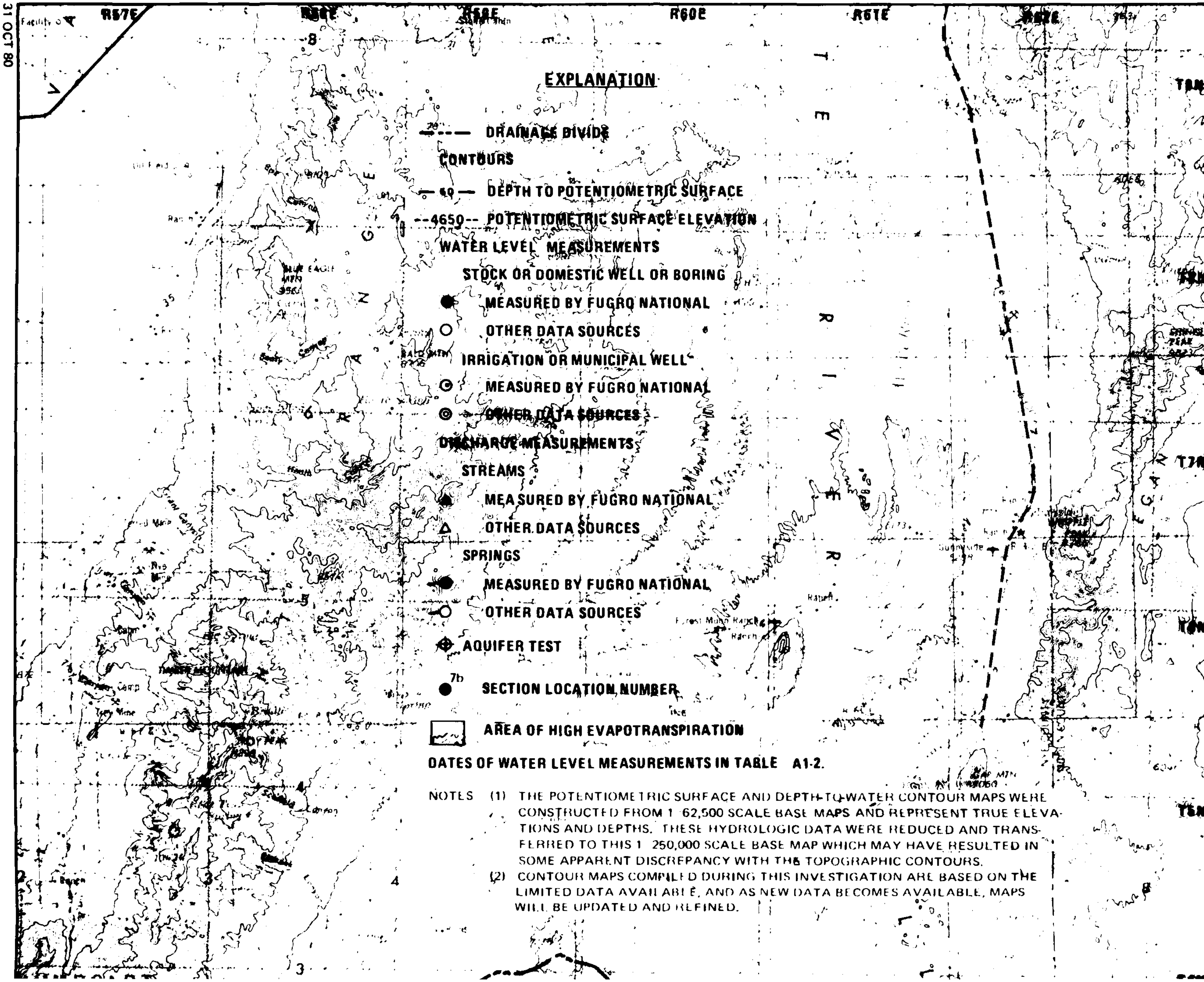
POTENTIOMETRIC LEVEL
BIG SAND SPRING VALLEY, NEVADA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE BMO

FIGURE B1-1

FUGRO NATIONAL, INC.

3


R57E
R58E
R59E
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R62E
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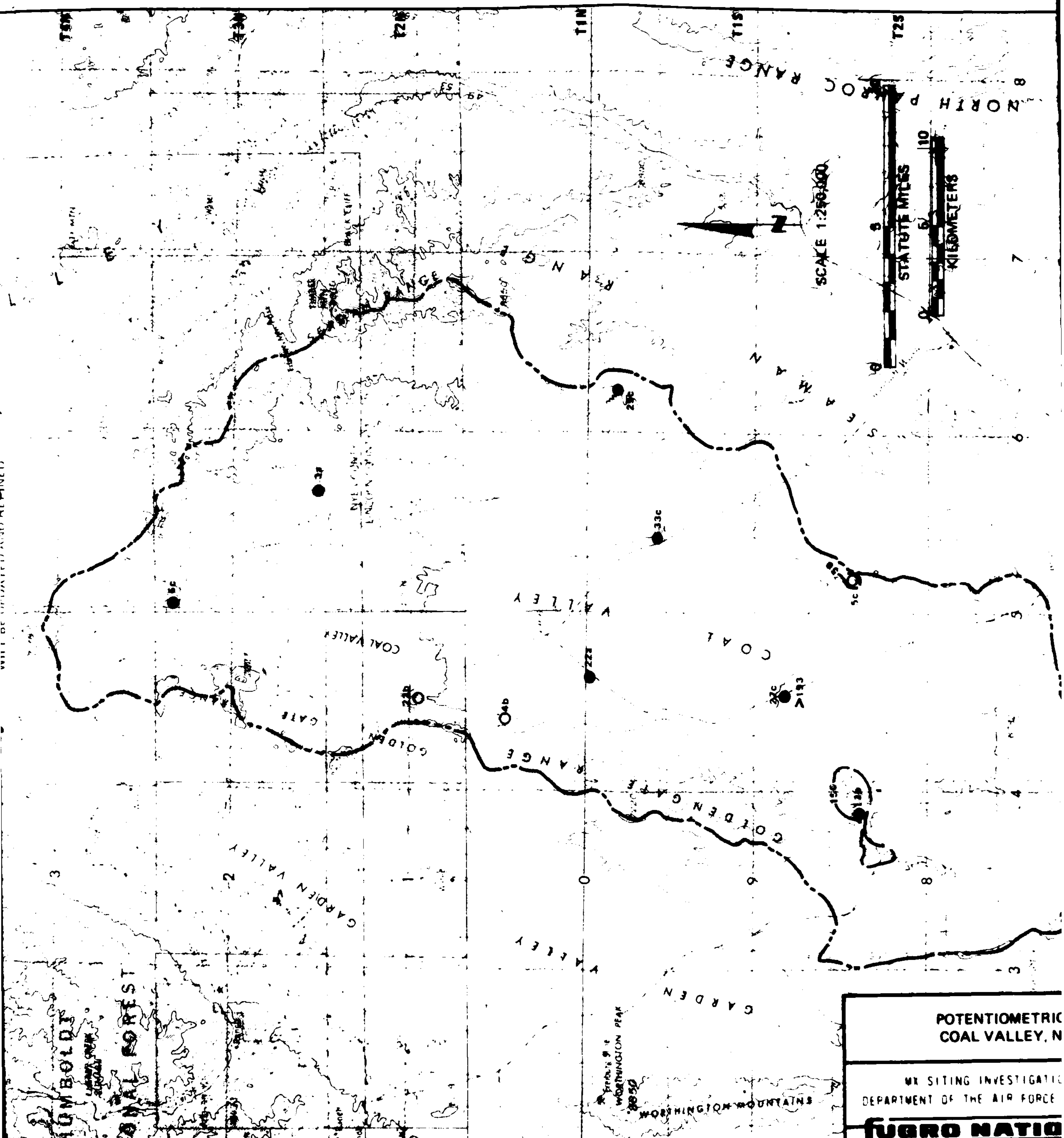
EXPLANATION
DRAINAGE DIVIDE
CONTOURS
60 DEPTH TO POTENTIOMETRIC SURFACE
--4650-- POTENTIOMETRIC SURFACE ELEVATION
WATER LEVEL MEASUREMENTS
STOCK OR DOMESTIC WELL OR BORING
MEASURED BY FUGRO NATIONAL
OTHER DATA SOURCES
IRRIGATION OR MUNICIPAL WELL
MEASURED BY FUGRO NATIONAL
OTHER DATA SOURCES
DISCHARGE MEASUREMENTS
STREAMS
MEASURED BY FUGRO NATIONAL
OTHER DATA SOURCES
SPRINGS
MEASURED BY FUGRO NATIONAL
OTHER DATA SOURCES
AQUIFER TEST
7b SECTION LOCATION NUMBER
AREA OF HIGH EVAPOTRANSPIRATION
DATES OF WATER LEVEL MEASUREMENTS IN TABLE A1-2.
NOTES (1) THE POTENTIOMETRIC SURFACE AND DEPTH-TO-WATER CONTOUR MAPS WERE CONSTRUCTED FROM 1:62,500 SCALE BASE MAPS AND REPRESENT TRUE ELEVATIONS AND DEPTHS. THESE HYDROLOGIC DATA WERE REDUCED AND TRANSFERRED TO THIS 1:250,000 SCALE BASE MAP WHICH MAY HAVE RESULTED IN SOME APPARENT DISCREPANCY WITH THE TOPOGRAPHIC CONTOURS.
(2) CONTOUR MAPS COMPILED DURING THIS INVESTIGATION ARE BASED ON THE LIMITED DATA AVAILABLE, AND AS NEW DATA BECOMES AVAILABLE, MAPS WILL BE UPDATED AND REFINED.

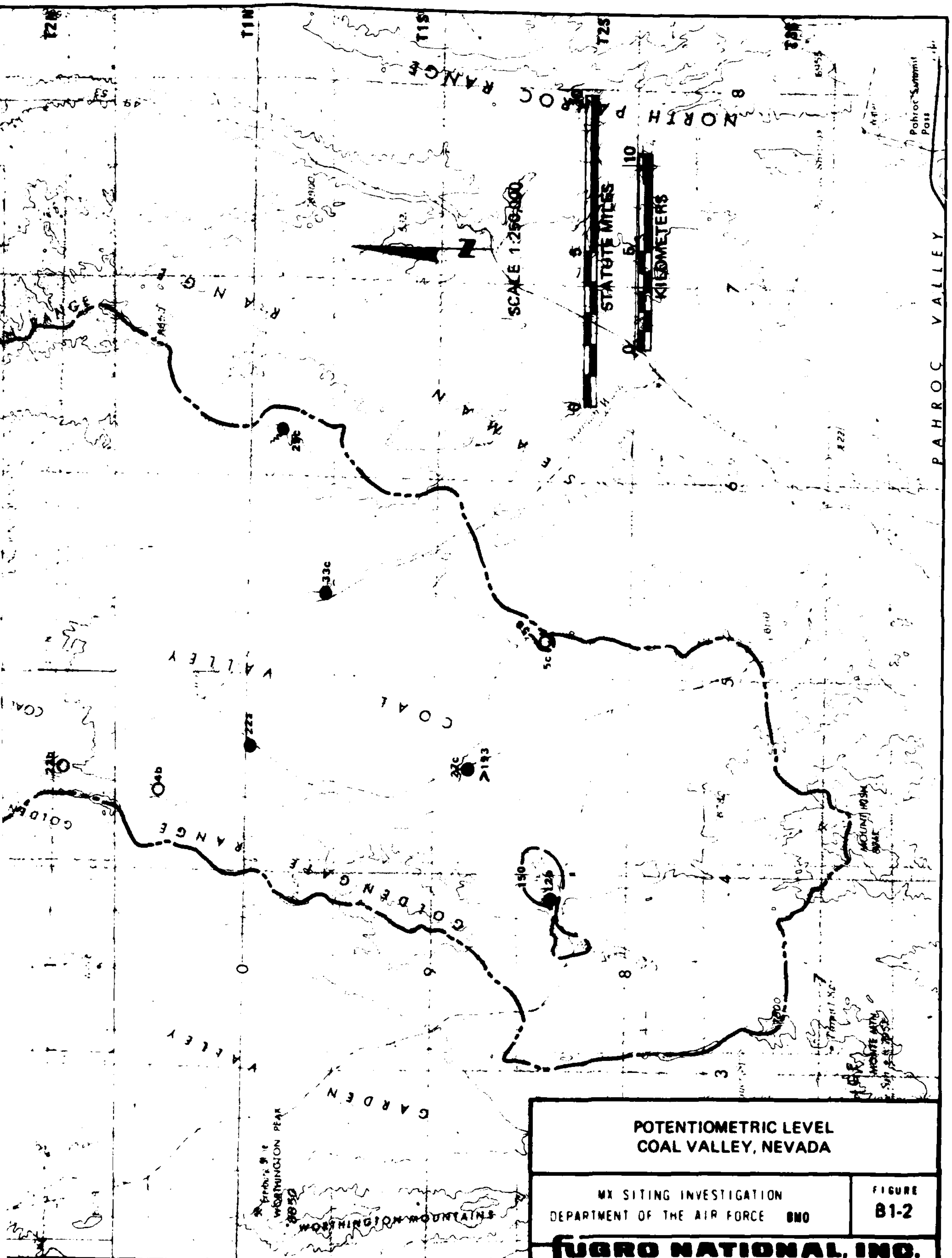


POTENTIOMETRIC
COAL VALLEY, N

MX SITING INVESTIGATIO
DEPARTMENT OF THE AIR FORCE

FUGRO NATIO

2

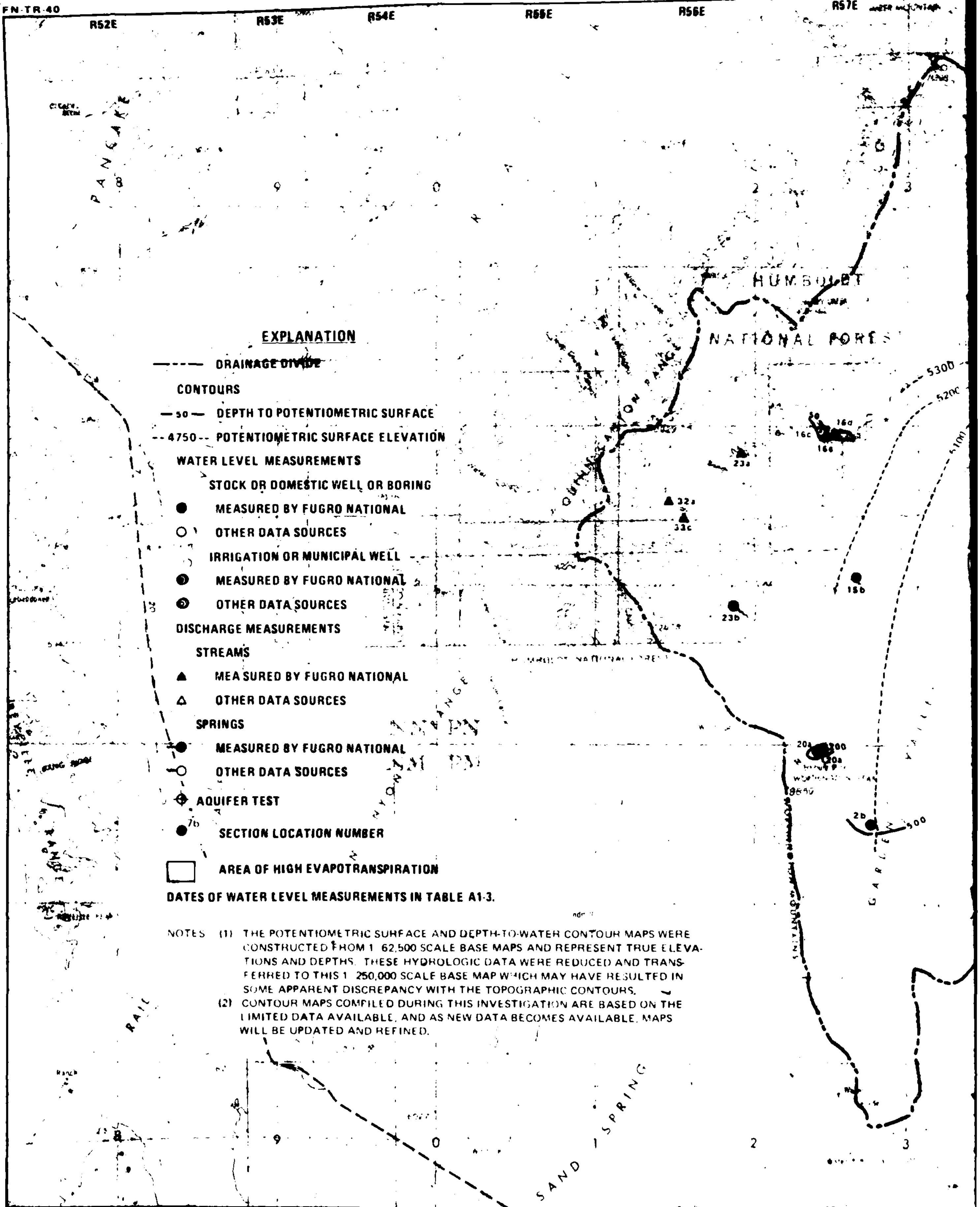


POTENTIOMETRIC LEVEL
COAL VALLEY, NEVADA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE BMO

FIGURE
B1-2

FUGRO NATIONAL, INC.


R52E
R53E
R54E
R55E
R56E
R57E
HUMBOLDT
NATIONAL FOREST
EXPLANATION
DRAINAGE DIVIDE
CONTOURS
50 DEPTH TO POTENTIOMETRIC SURFACE
4750 POTENTIOMETRIC SURFACE ELEVATION
WATER LEVEL MEASUREMENTS
STOCK OR DOMESTIC WELL OR BORING
MEASURED BY FUGRO NATIONAL
OTHER DATA SOURCES
IRRIGATION OR MUNICIPAL WELL
MEASURED BY FUGRO NATIONAL
OTHER DATA SOURCES
DISCHARGE MEASUREMENTS
STREAMS
MEASURED BY FUGRO NATIONAL
OTHER DATA SOURCES
SPRINGS
MEASURED BY FUGRO NATIONAL
OTHER DATA SOURCES
AQUIFER TEST
7b SECTION LOCATION NUMBER
AREA OF HIGH EVAPOTRANSPIRATION
DATES OF WATER LEVEL MEASUREMENTS IN TABLE A1-3.
NOTES (1) THE POTENTIOMETRIC SURFACE AND DEPTH-TO-WATER CONTOUR MAPS WERE CONSTRUCTED FROM 1:62,500 SCALE BASE MAPS AND REPRESENT TRUE ELEVATIONS AND DEPTHS. THESE HYDROLOGIC DATA WERE REDUCED AND TRANSFERRED TO THIS 1:250,000 SCALE BASE MAP WHICH MAY HAVE RESULTED IN SOME APPARENT DISCREPANCY WITH THE TOPOGRAPHIC CONTOURS.
(2) CONTOUR MAPS COMPILED DURING THIS INVESTIGATION ARE BASED ON THE LIMITED DATA AVAILABLE, AND AS NEW DATA BECOMES AVAILABLE, MAPS WILL BE UPDATED AND REFINED.
5300
5200
16a
16c
16b
23a
32a
33c
15b
23b
20a
20a
2b
5500
SAND SPRING
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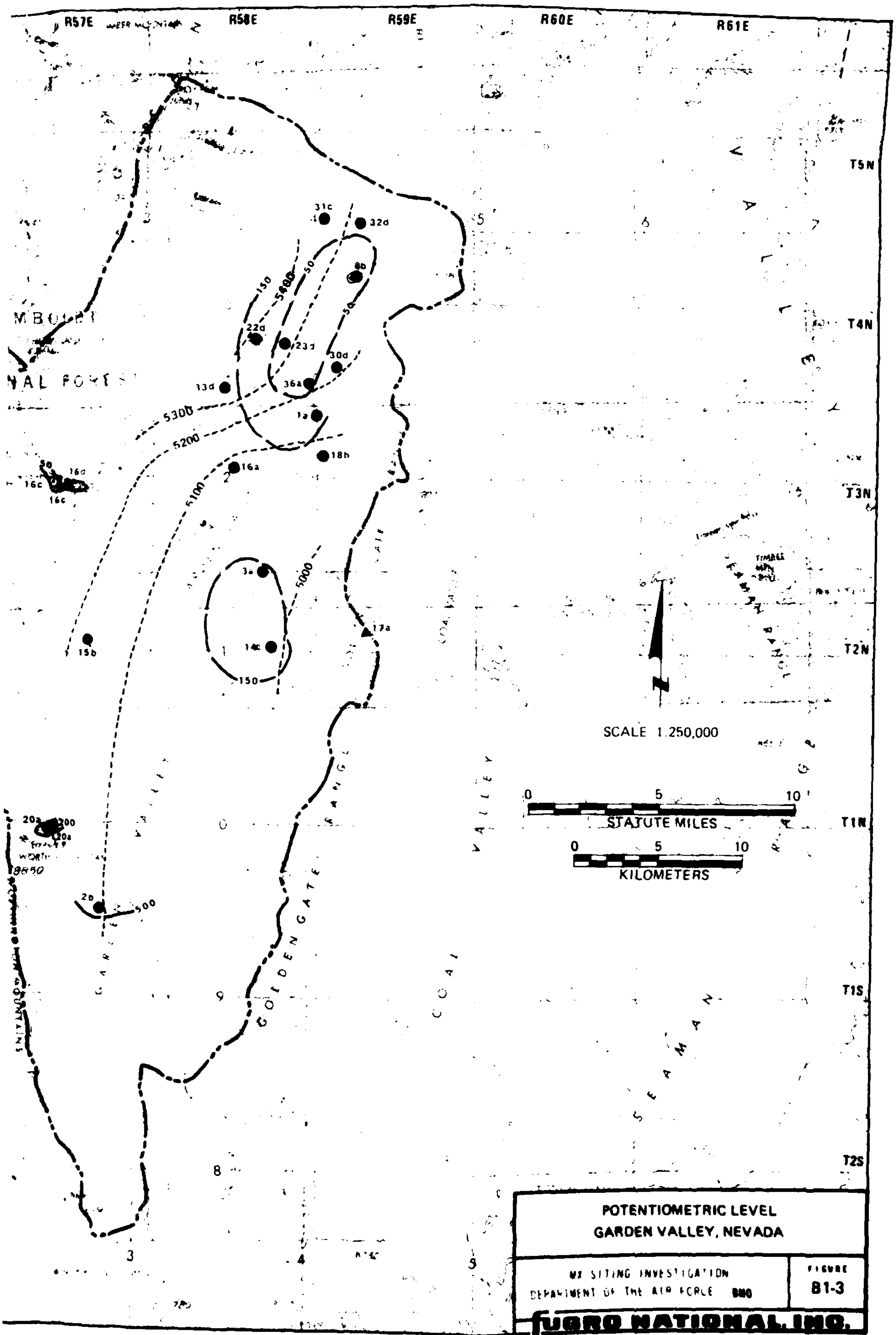
9
0
1
2
3

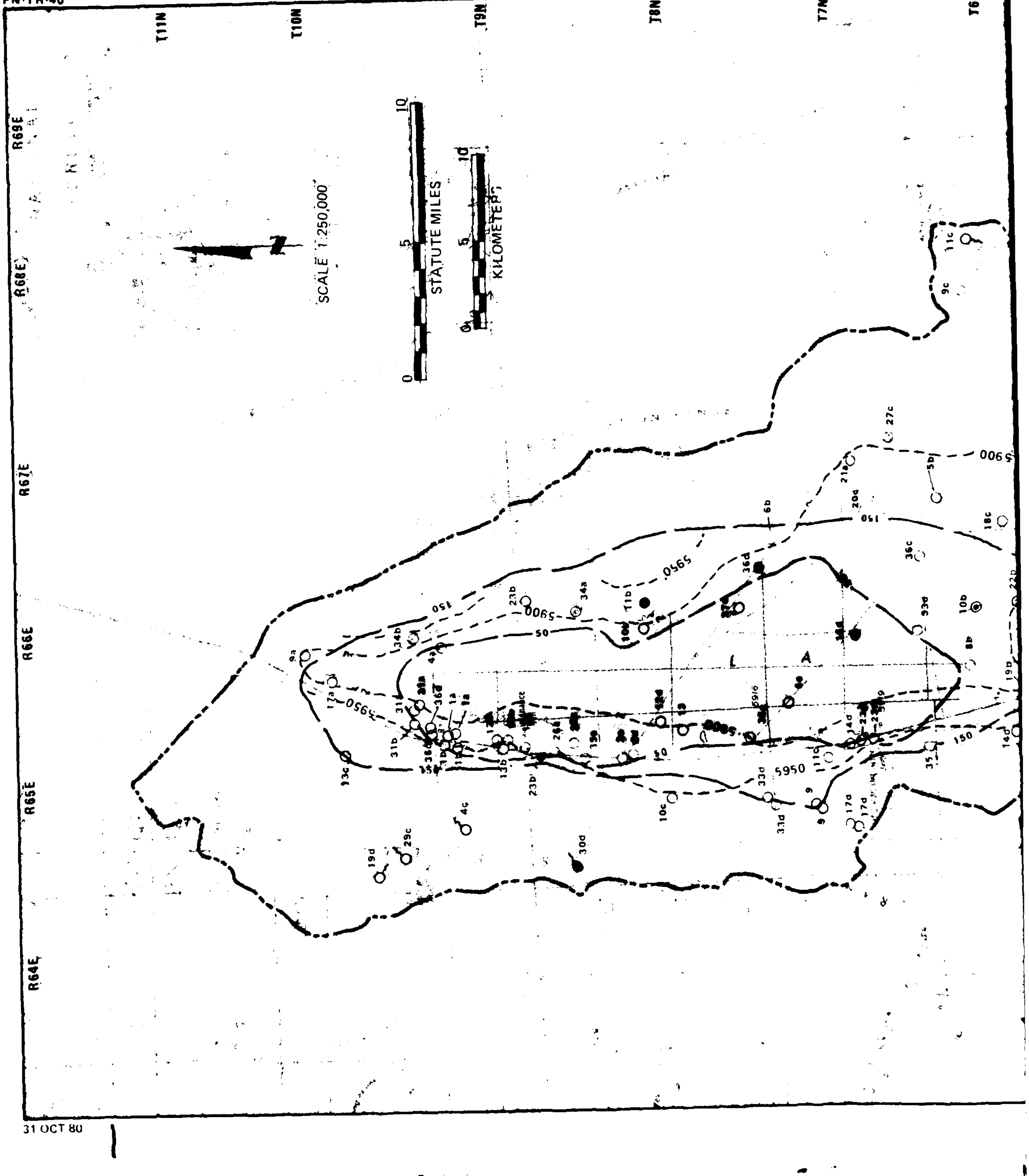


POTENTIOMETRIC LEVEL
GARDEN VALLEY, NEVADA

MX SITING INVESTIGATION DEPARTMENT OF THE AIR FORCE - BMO	FIGURE B1-3

FUGRO NATIONAL, INC.

2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R66E
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R64E
SCALE 1:250,000
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150
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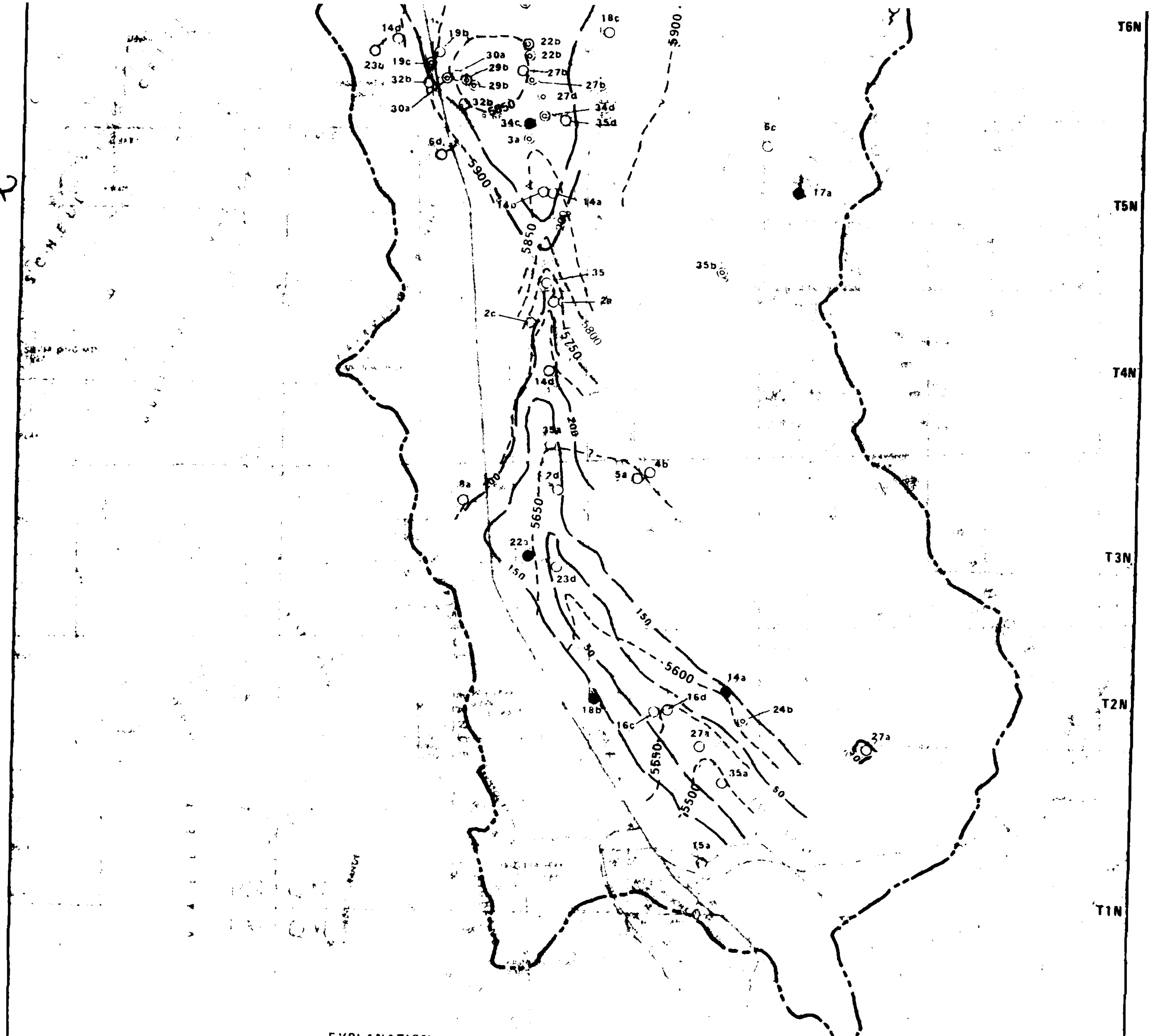
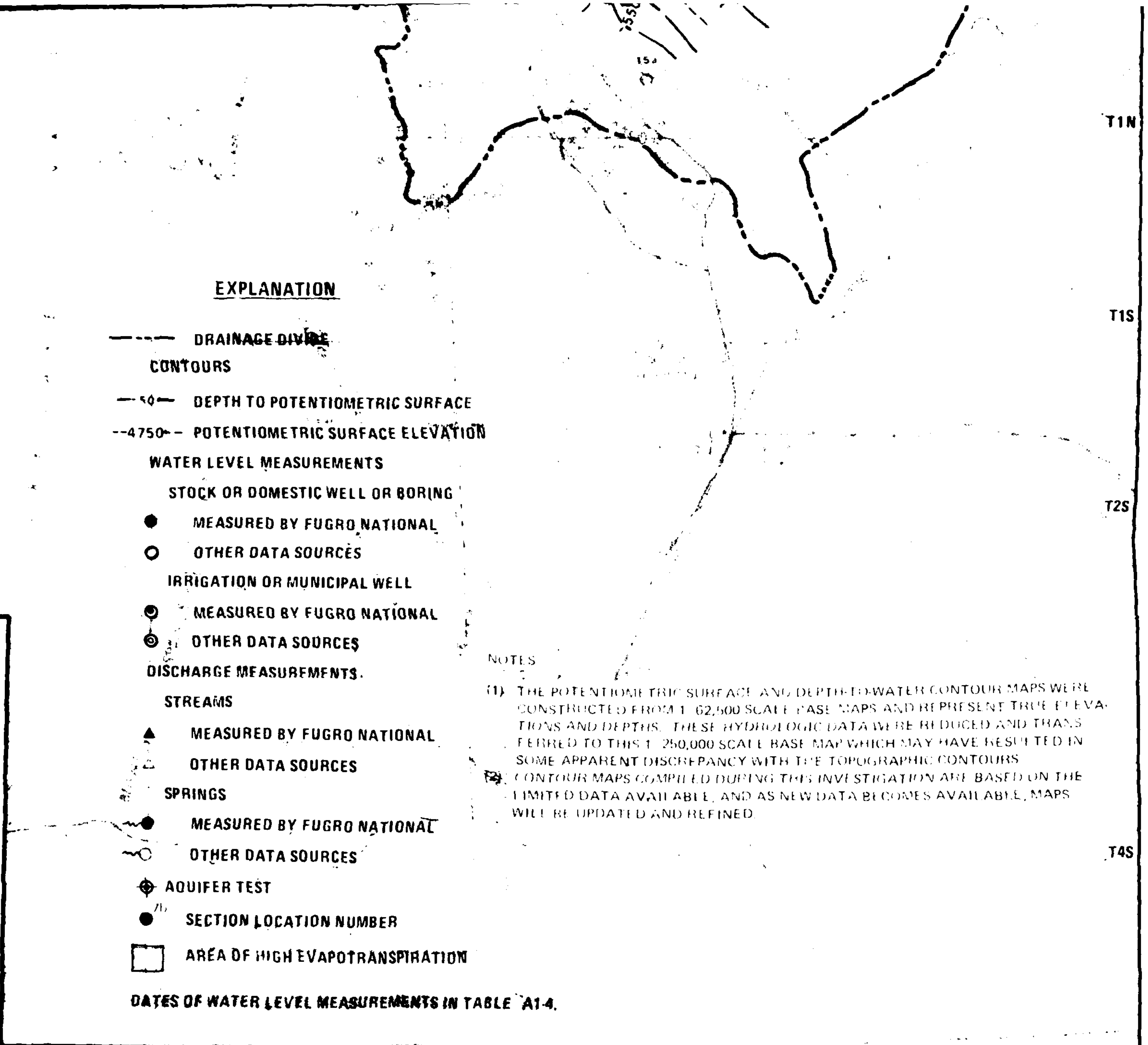
L
A



EXPLANATION

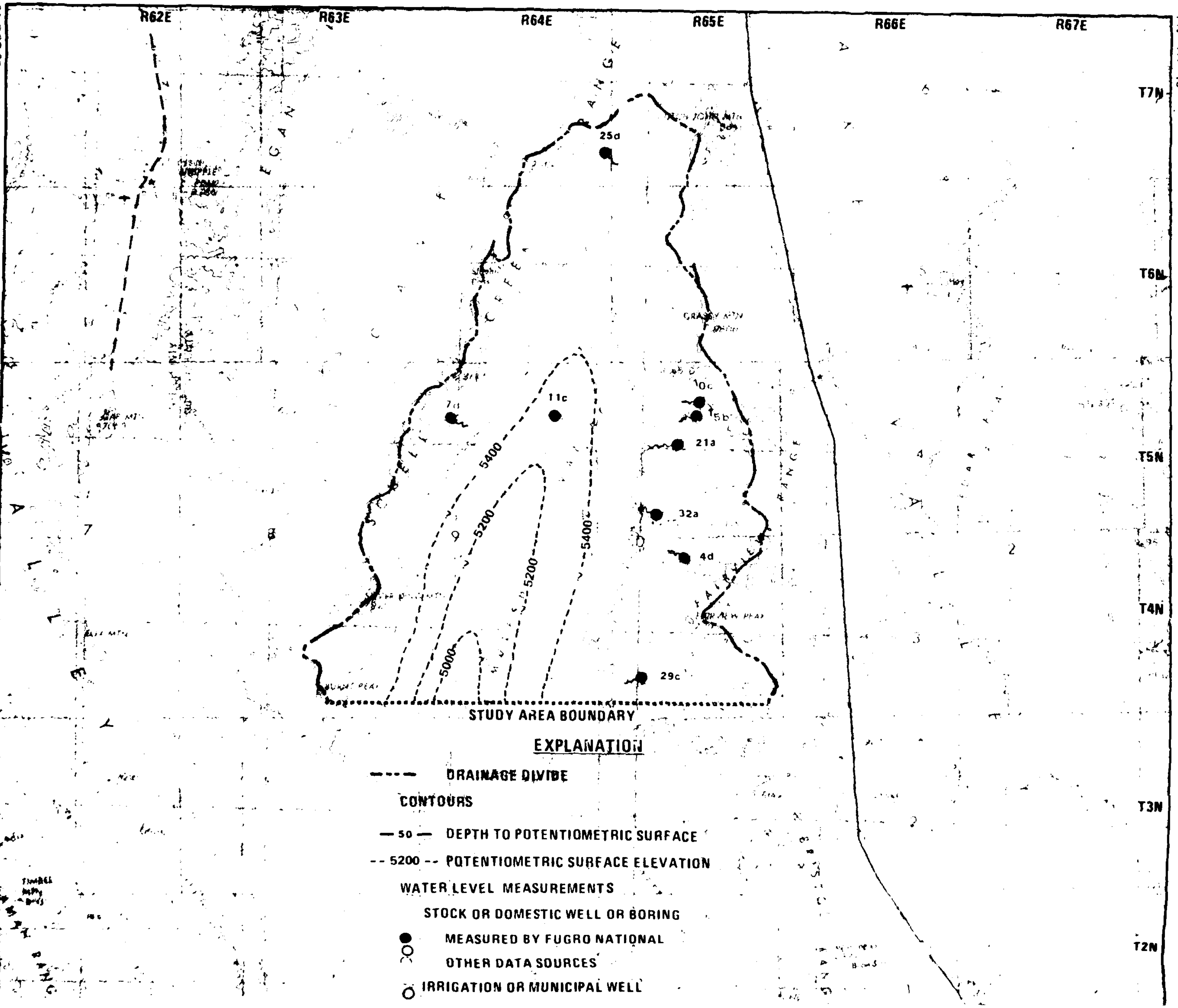


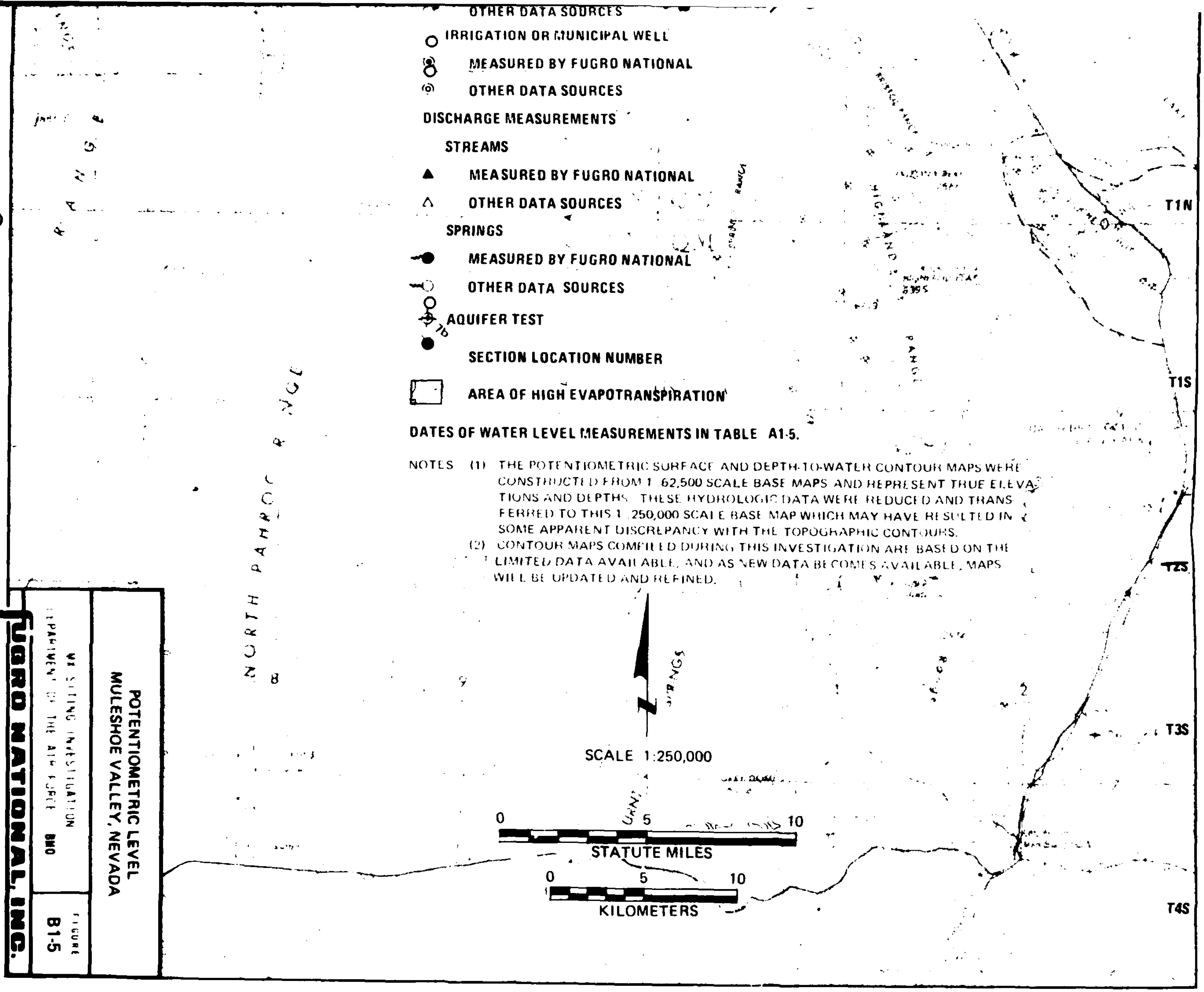
POTENTIOMETRIC LEVEL
LAKE VALLEY, NEVADA

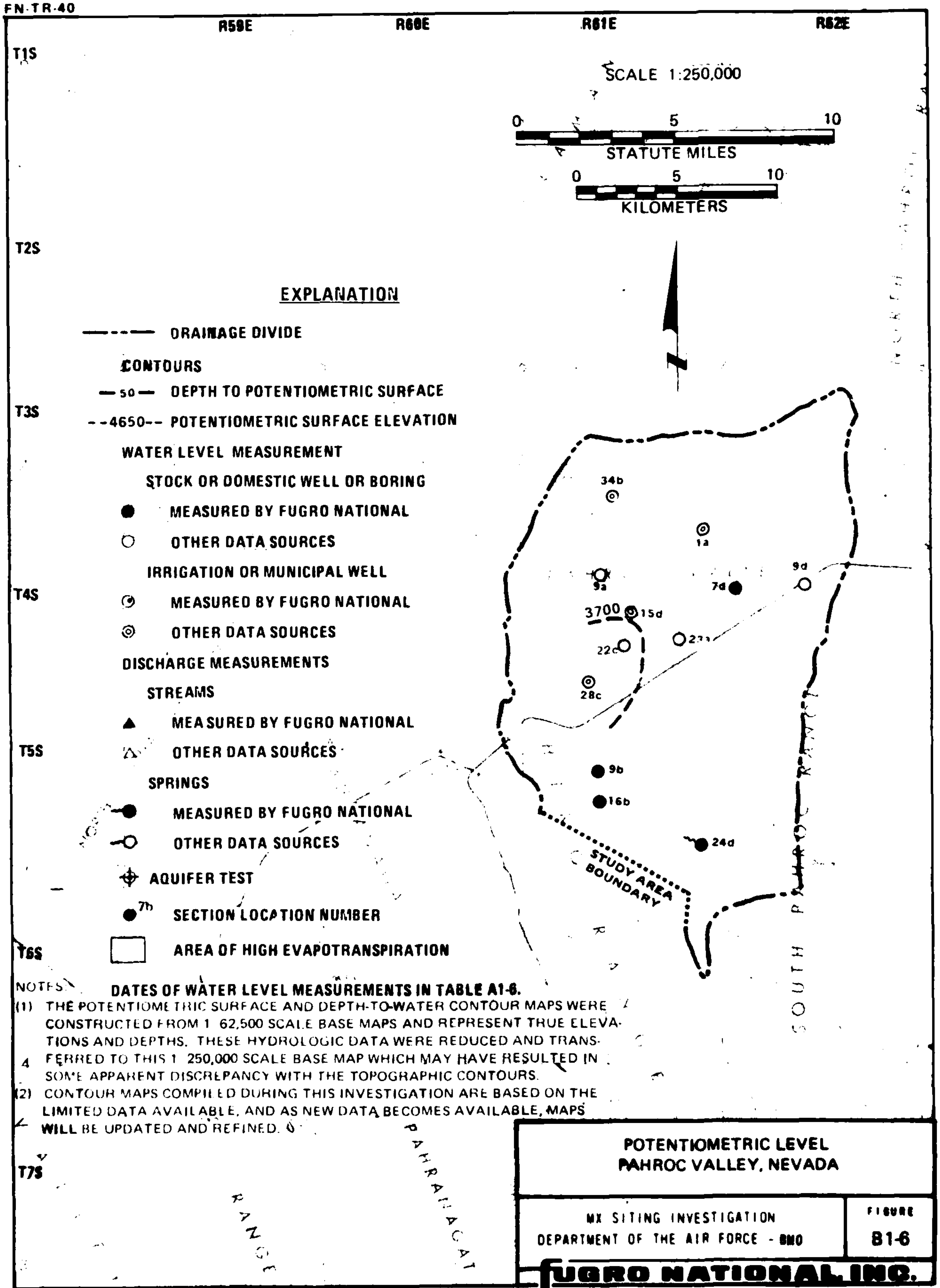
MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE BMO

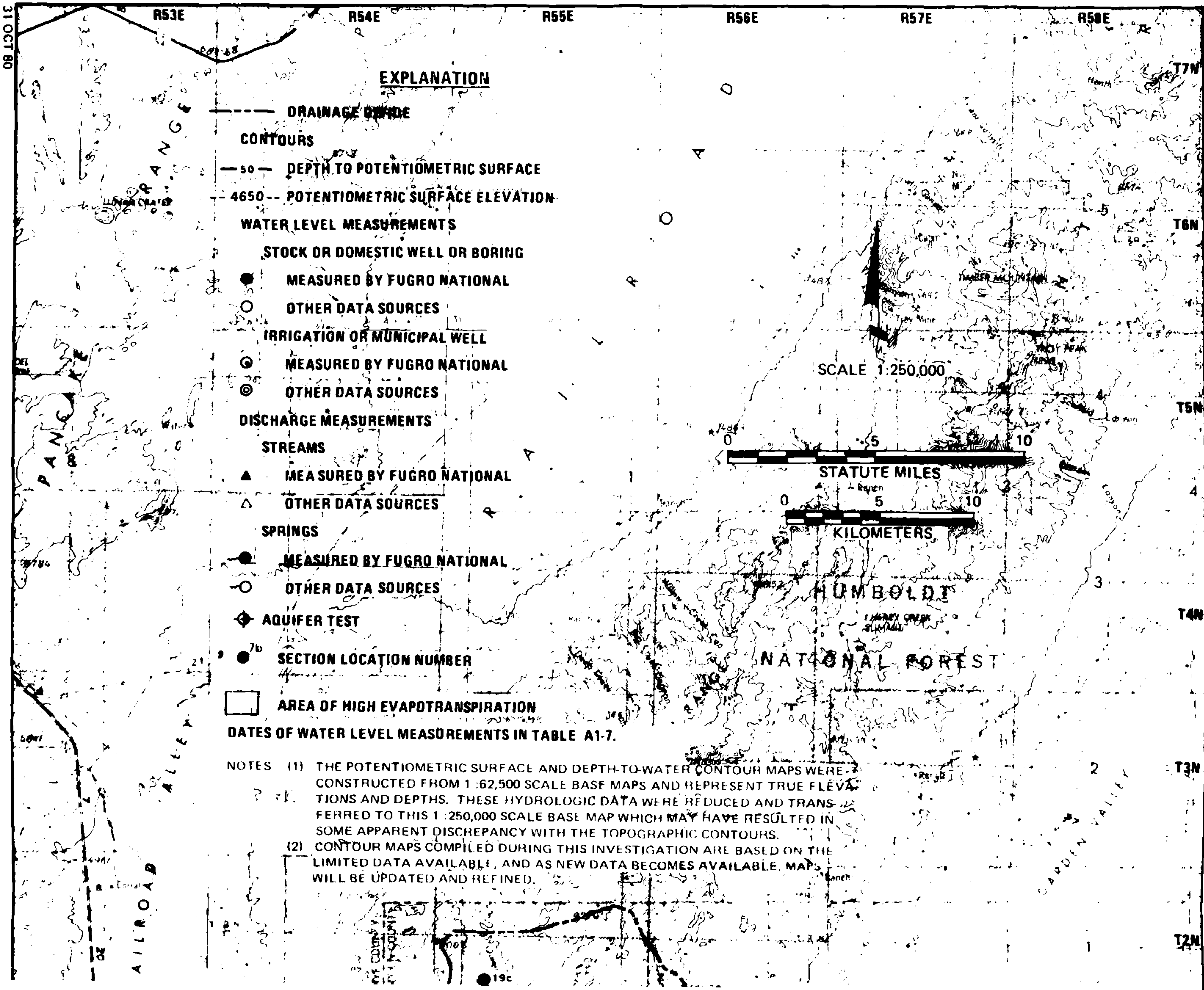
FIGURE B1-4

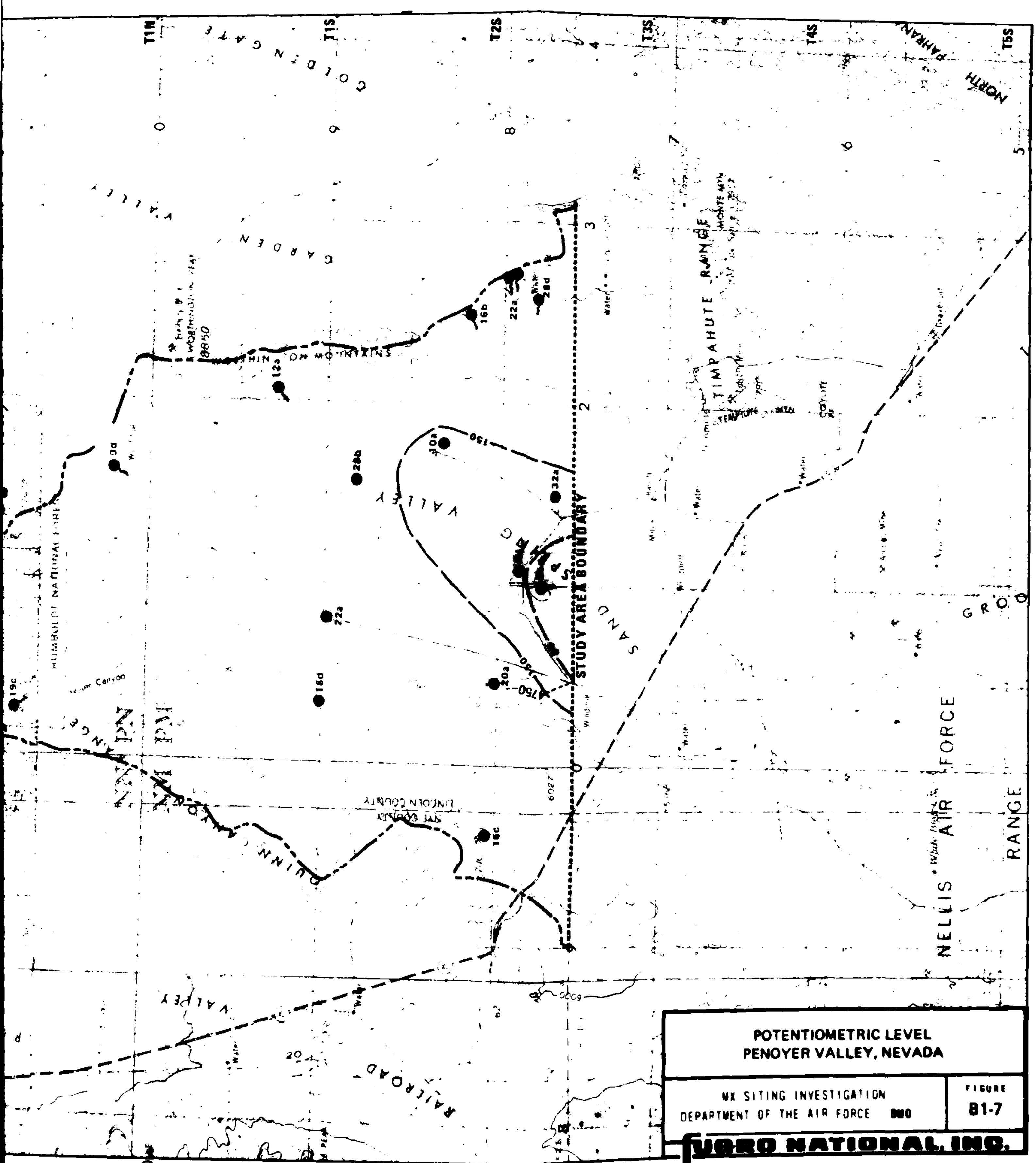
FUGRO NATIONAL, INC.


R62E
R63E
R64E
R65E
R66E
R67E
T7N
T6N
T5N
T4N
T3N
T2N
25d
10c
5b
21a
11c
7a
32a
4d
29c
5400
5200
5000
STUDY AREA BOUNDARY
EXPLANATION
DRAINAGE DIVIDE
CONTOURS
50 DEPTH TO POTENTIOMETRIC SURFACE
5200 POTENTIOMETRIC SURFACE ELEVATION
WATER LEVEL MEASUREMENTS
STOCK OR DOMESTIC WELL OR BORING
MEASURED BY FUGRO NATIONAL
OTHER DATA SOURCES
IRRIGATION OR MUNICIPAL WELL


OTHER DATA SOURCES
IRRIGATION OR MUNICIPAL WELL
MEASURED BY FUGRO NATIONAL
OTHER DATA SOURCES
DISCHARGE MEASUREMENTS
STREAMS
MEASURED BY FUGRO NATIONAL
OTHER DATA SOURCES
SPRINGS
MEASURED BY FUGRO NATIONAL
OTHER DATA SOURCES
AQUIFER TEST
7b
SECTION LOCATION NUMBER
AREA OF HIGH EVAPOTRANSPIRATION
DATES OF WATER LEVEL MEASUREMENTS IN TABLE A1-5.
NOTES (1) THE POTENTIOMETRIC SURFACE AND DEPTH-TO-WATER CONTOUR MAPS WERE CONSTRUCTED FROM 1:62,500 SCALE BASE MAPS AND REPRESENT TRUE ELEVATIONS AND DEPTHS. THESE HYDROLOGIC DATA WERE REDUCED AND TRANSFERRED TO THIS 1:250,000 SCALE BASE MAP WHICH MAY HAVE RESULTED IN SOME APPARENT DISCREPANCY WITH THE TOPOGRAPHIC CONTOURS.
(2) CONTOUR MAPS COMPILED DURING THIS INVESTIGATION ARE BASED ON THE LIMITED DATA AVAILABLE, AND AS NEW DATA BECOMES AVAILABLE, MAPS WILL BE UPDATED AND REFINED.
T1N
T1S
T2S
T3S
T4S
HIGHLAND
RANGE
NORTH PAHROC RANGE
SPRINGS
SCALE 1:250,000
0
5
10
STATUTE MILES
0
5
10
KILOMETERS
POTENTIOMETRIC LEVEL
MULESHOE VALLEY, NEVADA
MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE BMO
FIGURE
B1-5
FUGRO NATIONAL, INC.


R59E
R60E
R61E
R62E
T1S
T2S
T3S
T4S
T5S
T6S
T7S
SCALE 1:250,000
0 5 10
STATUTE MILES
0 5 10
KILOMETERS
EXPLANATION
DRAINAGE DIVIDE
CONTOURS
—50— DEPTH TO POTENTIOMETRIC SURFACE
--4650-- POTENTIOMETRIC SURFACE ELEVATION
WATER LEVEL MEASUREMENT
STOCK OR DOMESTIC WELL OR BORING
MEASURED BY FUGRO NATIONAL
OTHER DATA SOURCES
IRRIGATION OR MUNICIPAL WELL
MEASURED BY FUGRO NATIONAL
OTHER DATA SOURCES
DISCHARGE MEASUREMENTS
STREAMS
MEASURED BY FUGRO NATIONAL
OTHER DATA SOURCES
SPRINGS
MEASURED BY FUGRO NATIONAL
OTHER DATA SOURCES
AQUIFER TEST
7h SECTION LOCATION NUMBER
AREA OF HIGH EVAPOTRANSPIRATION
NOTES: DATES OF WATER LEVEL MEASUREMENTS IN TABLE A1-6.
(1) THE POTENTIOMETRIC SURFACE AND DEPTH-TO-WATER CONTOUR MAPS WERE CONSTRUCTED FROM 1:62,500 SCALE BASE MAPS AND REPRESENT TRUE ELEVATIONS AND DEPTHS. THESE HYDROLOGIC DATA WERE REDUCED AND TRANSFERRED TO THIS 1:250,000 SCALE BASE MAP WHICH MAY HAVE RESULTED IN SOME APPARENT DISCREPANCY WITH THE TOPOGRAPHIC CONTOURS.
(2) CONTOUR MAPS COMPILED DURING THIS INVESTIGATION ARE BASED ON THE LIMITED DATA AVAILABLE, AND AS NEW DATA BECOMES AVAILABLE, MAPS WILL BE UPDATED AND REFINED.
34b
1a
9a
7d
9d
3700
15d
22c
28c
9b
16b
24d
STUDY AREA BOUNDARY
SOUTH PAHROC RANGE
PAHRANAGAT RANGE
POTENTIOMETRIC LEVEL
PAHROC VALLEY, NEVADA
MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - BMO
FIGURE
B1-6
FUGRO NATIONAL, INC.


R53E
R54E
R55E
R56E
R57E
R58E
T7N
T6N
T5N
T4N
T3N
T2N
EXPLANATION
DRAINAGE DIVIDE
CONTOURS
50 DEPTH TO POTENTIOMETRIC SURFACE
4650 POTENTIOMETRIC SURFACE ELEVATION
WATER LEVEL MEASUREMENTS
STOCK OR DOMESTIC WELL OR BORING
MEASURED BY FUGRO NATIONAL
OTHER DATA SOURCES
IRRIGATION OR MUNICIPAL WELL
MEASURED BY FUGRO NATIONAL
OTHER DATA SOURCES
DISCHARGE MEASUREMENTS
STREAMS
MEASURED BY FUGRO NATIONAL
OTHER DATA SOURCES
SPRINGS
MEASURED BY FUGRO NATIONAL
OTHER DATA SOURCES
AQUIFER TEST
7b SECTION LOCATION NUMBER
AREA OF HIGH EVAPOTRANSPIRATION
DATES OF WATER LEVEL MEASUREMENTS IN TABLE A1-7.
NOTES (1) THE POTENTIOMETRIC SURFACE AND DEPTH-TO-WATER CONTOUR MAPS WERE CONSTRUCTED FROM 1:62,500 SCALE BASE MAPS AND REPRESENT TRUE ELEVATIONS AND DEPTHS. THESE HYDROLOGIC DATA WERE REDUCED AND TRANSFERRED TO THIS 1:250,000 SCALE BASE MAP WHICH MAY HAVE RESULTED IN SOME APPARENT DISCREPANCY WITH THE TOPOGRAPHIC CONTOURS.
(2) CONTOUR MAPS COMPILED DURING THIS INVESTIGATION ARE BASED ON THE LIMITED DATA AVAILABLE, AND AS NEW DATA BECOMES AVAILABLE, MAPS WILL BE UPDATED AND REFINED.
SCALE 1:250,000
0 5 10
STATUTE MILES
0 5 10
KILOMETERS
HUMBOLDT
NATIONAL FOREST
RANGE
RAILROAD
GARDEN VALLEY
19c



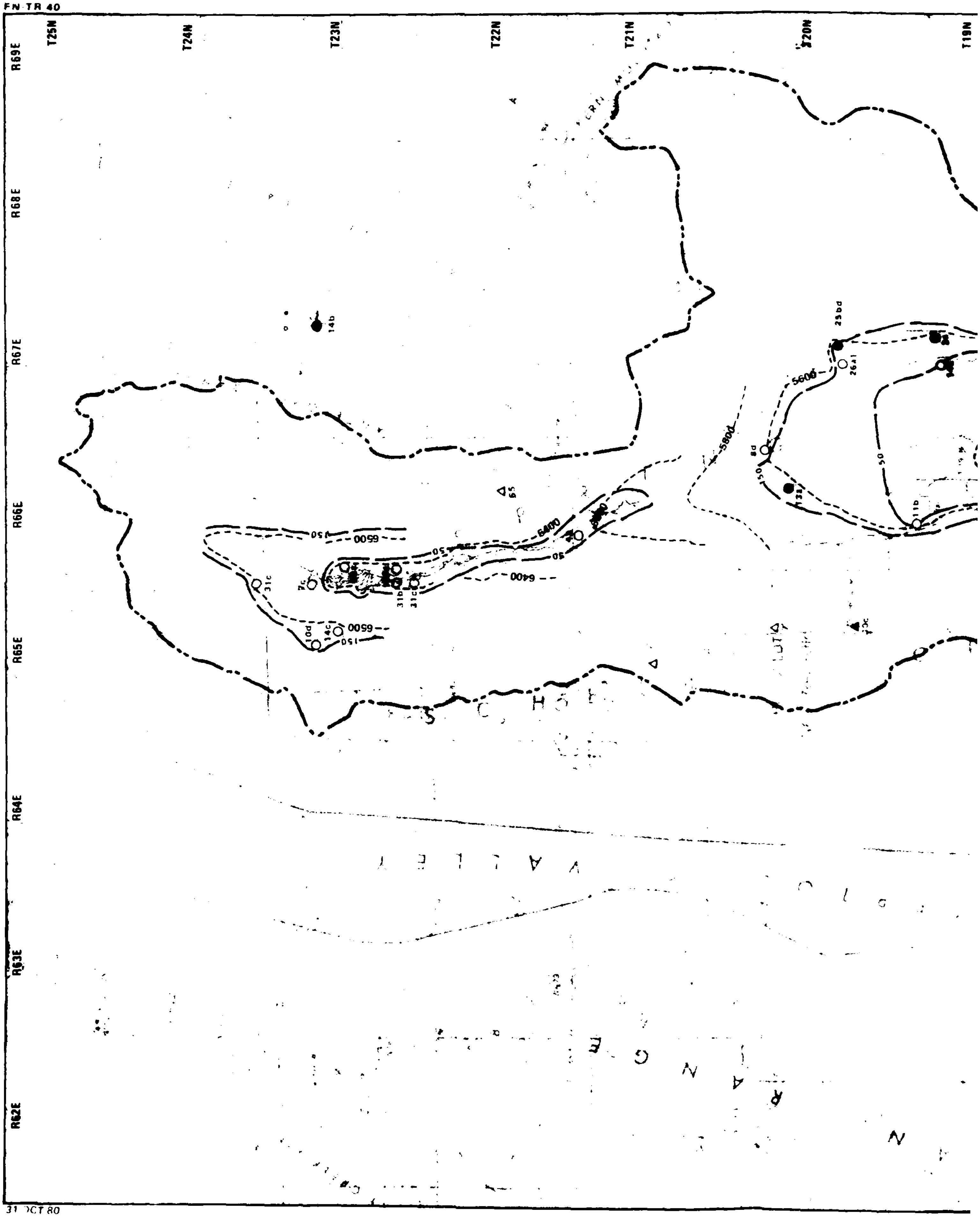
POTENTIOMETRIC LEVEL
PENOYER VALLEY, NEVADA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE BMO

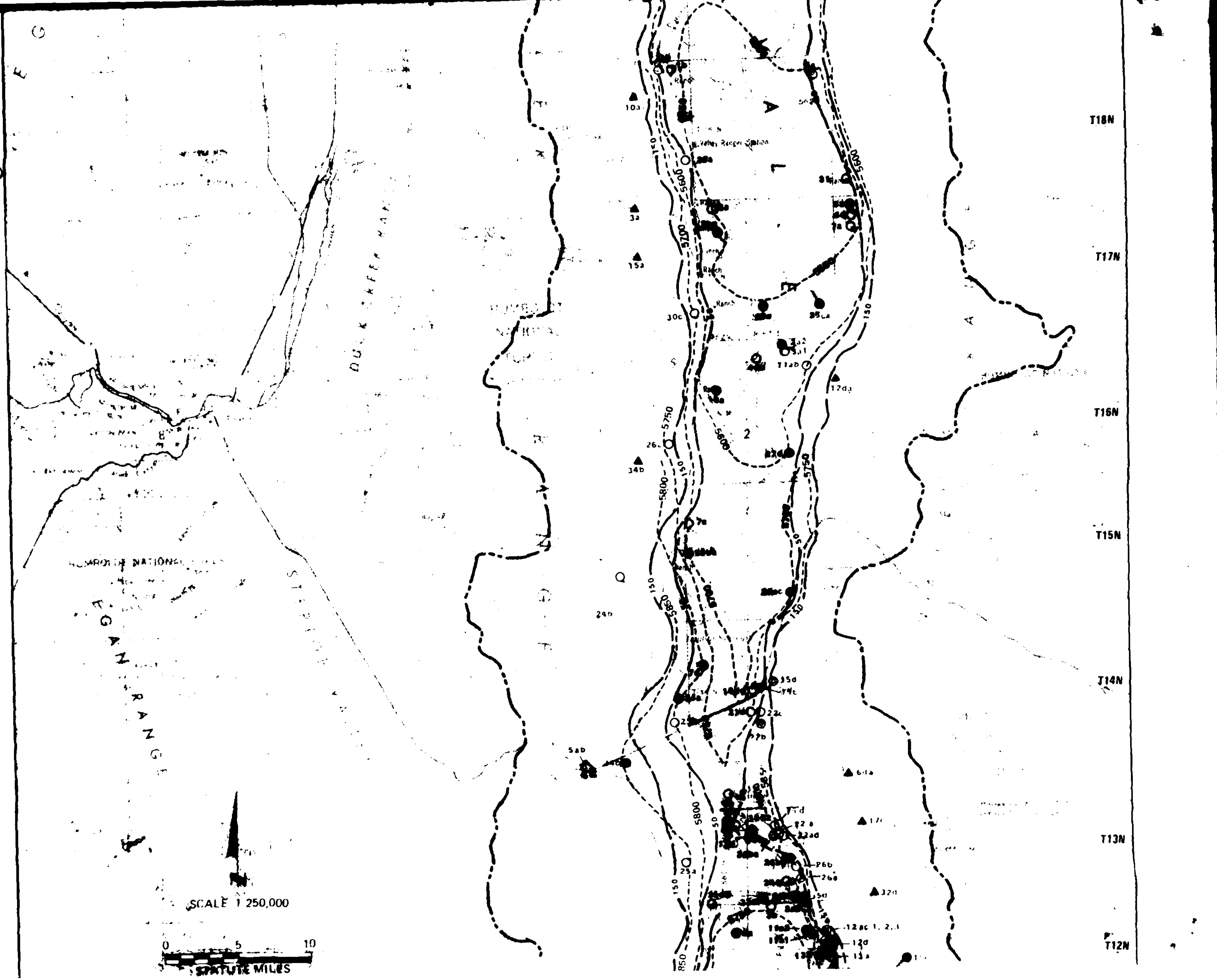
FIGURE B1-7

FUGRO NATIONAL, INC.

FN-TR 40

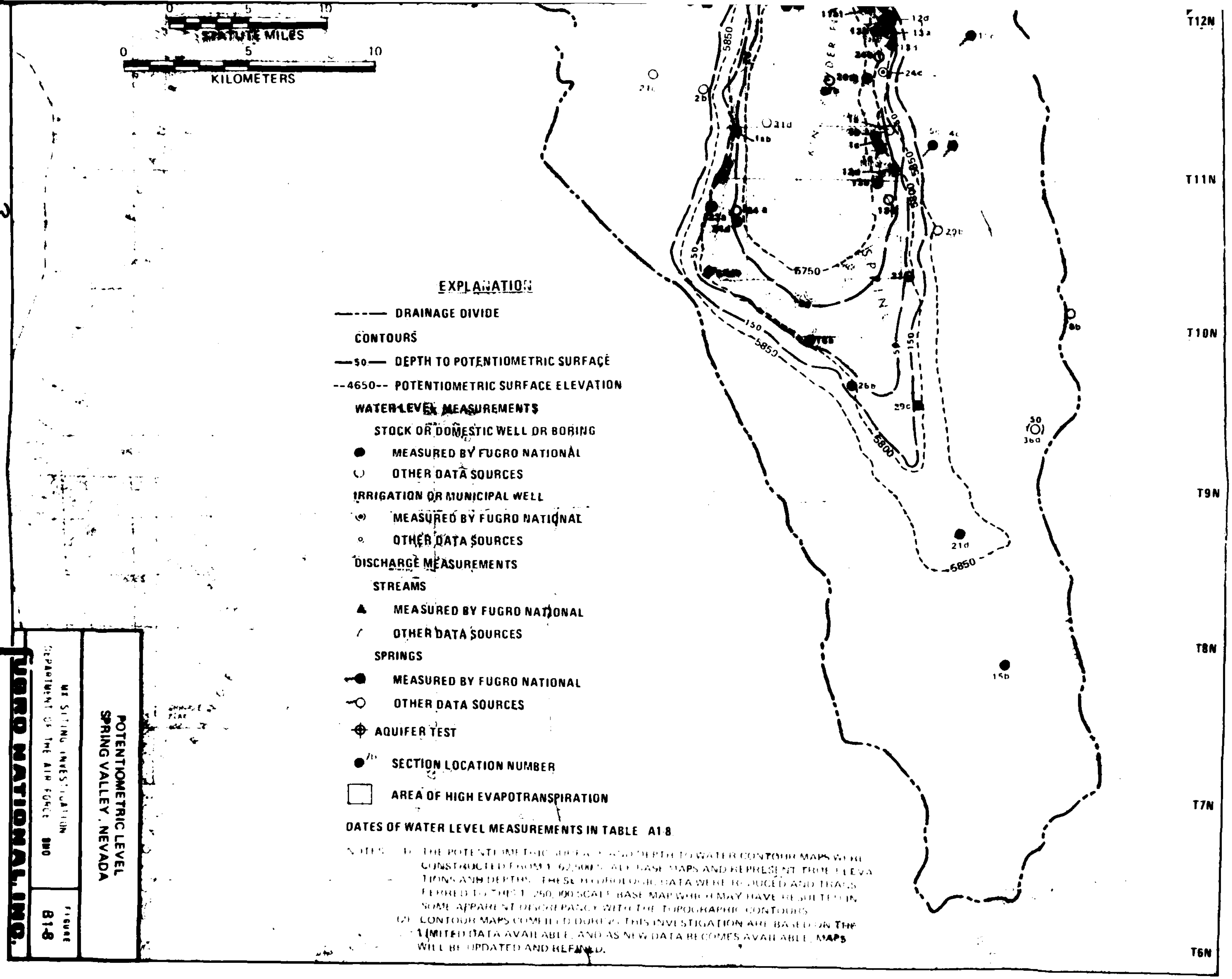


31 OCT 80



T18N
T17N
T16N
T15N
T14N
T13N
T12N
Valley Ranger Station
Ranch
5600
5700
5750
5800
5850
150
10a
3a
15a
30c
26
34b
24b
5ab
25a
12da
6la
32d
35d
22c
22ad
26b
26a
12ac 1, 2, 3
12d
13a
DUCK CREEK RANGE
HUMBOLDT NATIONAL
EGAN RANGE
SCALE 1 250,000
0
5
10
STATUTE MILES

2



POTENTIOMETRIC LEVEL
SPRING VALLEY, NEVADA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE BMO

FIGURE B1-8

FUGRO NATIONAL, INC.

3

APPENDIX C1.0

WATER-QUALITY ANALYSES

APPENDIX C

TABLE OF CONTENTS

SUBSTANCE OR PROPERTY	SUITABILITY FOR DRINKING		
	GOOD	POOR	EXCEEDS CRITERIA
CALCIUM	< 75	75-200	> 200
MAGNESIUM	< 50	50-150	> 150
SULFATE	< 250	250-400	> 400
CHLORIDE	< 250	250-600	> 600
FLUORIDE*	< 0.8	0.8-1.4	> 1.4
NITRATE (as N)	-	-	> 10
TOTAL DISSOLVED SOLIDS	< 500	500-1500	> 1500

* RECOMMENDED FLUORIDE LEVELS VARY WITH THE ANNUAL AVERAGE DAILY MAXIMUM AIR TEMPERATURE. BECAUSE THIS AVERAGE HAS NOT BEEN CALCULATED FOR EACH VALLEY, THE LOWER LIMITS, AS SET BY THE E.P.A., WERE USED.

NOTE: CRITERIA ARE BASED ON U.S. PUBLIC HEALTH SERVICE, 1962, U.S. ENVIRONMENTAL PROTECTION AGENCY, 1976, AND WORLD HEALTH ORGANIZATION, 1963, STANDARDS FOR DRINKING WATER IN mg/l. BICARBONATE, CARBONATE, POTASSIUM, SILICA AND SODIUM CONCENTRATIONS WERE ALSO ANALYZED AND USED IN THE CALCULATION OF TOTAL DISSOLVED SOLIDS, BUT NO RECOMMENDED LIMITS HAVE BEEN ESTABLISHED FOR THESE SUBSTANCES

WATER QUALITY CRITERIA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - BMO

TABLE
C1-1

FUGRO NATIONAL, INC.

SAMPLE LOCATION	OWNER OR WATER USER	DATE OF COLLECTION (mo-yr)	FIELD DETERMINATIONS TEMPERATURE C	pH	SPECIFIC CONDUCTANCE (μmhos/cm @ 25°C)	BICARBONATE (HCO_3)	CARBONATE (CO_3)	DISSOLVED SOLIDS (see note)	CALCIUM (Ca)	MAGNESIUM (Mg)	SODIUM (Na)	POTASSIUM (K)	SULFATE (SO_4)	CHLORIDE (Cl)	FLUORIDE (F)	NITRATE (as N)	SILICA (SiO_2)	TRITIUM (pCi/liter)	REFERENCES	REMARKS
10N/52E-23aa	—	5-80	10	7.2	600	254	0	—	66	23	29	1	78	30	0.3	0.1	14	—		Squaw Wells Springs
8N/52E-1bd*	NRC	8-68	56	8.4	773	396	6	587	3.6	0.2	197	5.8	35	21	12	0.7	47	—	1	2279-6500' interval
do	do	8-68	36	8.3	1020	554	9	707	3.4	0.4	204	1.6	37	25	18	0.4	44	—	1	Same interval, 5 days later
do	do	9-68	34	7.7	338	162	0	331	14	0.8	57	12	22	7.7	1.4	5.7	66	—	1	5035-5225' interval
8N/52E-15bc*	NRC	8-68	30	7.4	494	245	0	452	6.6	1.4	115	2.2	39	10	6.4	0.5	28	—	1	3670-3842' interval
do	do	10-68	53	7.5	420	201	0	278	4.4	0.6	94	2.0	24	12	5.2	<0.1	39	—	1	4697-6009' interval
do	do	10-68	33	7.5	434	214	0	293	4.8	0.6	99	2.2	24	14	5.8	<0.1	36	—	1	5490-5810' interval
8N/53E-16ac*	NRC	1-69	22	8.2	315	135	0	266	19	0.6	46	5.6	29	8.8	1.0	6.6	81	—	1	870-890' interval
do	do	1-69	38	9.5	373	116	33	263	3.7	0.1	87	1.4	24	8.3	1.4	2.2	44	—	1	2020-2050' interval

* Only analyses from the uppermost aquifer(s) were used to define areas on the water quality drawings.

References:

1. Dinwiddie and Schroder, 1971

NOTE: SAMPLES FOR WATER QUALITY ANALYSIS COLLECTED BY FUGRO NATIONAL EXCEPT WHERE NOTED. ALL ANALYSIS USED IN mg/l EXCEPT WHERE NOTED. FUGRO NATIONAL ANALYSIS FOR DISSOLVED SOLIDS CALCULATED USING THE RESIDUE - ON - EVAPORATION AT 180 C METHOD. OTHER AUTHORS MAY USE DIFFERENT METHODS. NEVADA LOCATIONS BASED ON MT. DIABLO BASELINE AND UTAH LOCATIONS BASED ON SALT LAKE BASELINE AND MERIDIAN.

WATER QUALITY ANALYSES
BIG SAND SPRINGS VALLEY, NEVADA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE — BMO

TABLE C1-2

FUGRO NATIONAL, INC.

SAMPLE LOCATION	OWNER OR WATER USER	DATE OF COLLECTION (mo - yr)	FIELD DETERMINATIONS					DISSOLVED SOLIDS (see note)	CALCIUM (Ca)	MAGNESIUM (Mg)	SODIUM (Na)	POTASSIUM (K)	SULFATE (SO_4)	CHLORIDE (Cl)	FLUORIDE (F)	NITRATE (as N)	SILICA (SiO_2)	TRITIUM (pCi/liter)	REFERENCES	REMARKS
			TEMPERATURE °C	pH	SPECIFIC CONDUCTANCE (µmhos/cm @ 25°C)	BICARBONATE (HCO_3)	CARBONATE (CO_3)													
1N/61E-29ca	—	6-80	12	6.7	500	303	0	—	82	9.1	23	2	26	14	0.2	5.2	24	—		Oreana Spring

NOTE: SAMPLES FOR WATER QUALITY ANALYSIS COLLECTED BY FUGRO NATIONAL EXCEPT WHERE NOTED. ALL ANALYSIS USED IN mg/l EXCEPT WHERE NOTED. FUGRO NATIONAL ANALYSIS FOR DISSOLVED SOLIDS CALCULATED USING THE RESIDUE - ON - EVAPORATION AT 180 C METHOD. OTHER AUTHORS MAY USE DIFFERENT METHODS. NEVADA LOCATIONS BASED ON MT. DIABLO BASELINE AND UTAH LOCATIONS BASED ON SALT LAKE BASELINE AND MERIDIAN.

WATER QUALITY ANALYSES
COAL VALLEY, NEVADA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE — BMO

TABLE C1-3

FUGRO NATIONAL, INC.

SAMPLE LOCATION	OWNER OR WATER USER	DATE OF COLLECTION (mo - yr)	FIELD DETERMINATIONS					DISSOLVED SOLIDS (see note)	CALCIUM (Ca)	MAGNESIUM (Mg)	SODIUM (Na)	POTASSIUM (K)	SULFATE (SO_4)	CHLORIDE (Cl)	FLUORIDE (F)	NITRATE (as N)	SILICA (SiO_2)	TRITIUM (pCi/liter)	REFERENCES	REMARKS
			TEMPERATURE C	pH	SPECIFIC CONDUCTANCE (µmhos/cm @ 25 C)	BICARBONATE (HCO_3)	CARBONATE (CO_3)													
3N/56E-23aa	—	6-80	13	7.6	305	220	0	181	48	17	7.3	1.0	11	2.8	0.6	0.08	16	—		Southfork, Cottonwood Creek
3N/56E-32a	—	6-80	13	8.0	205	156	0	156	42	5.7	11	1.2	13	4.1	0.7	0.07	22	—		Cottonwood Creek
3N/57E-16c	—	6-80	13	8.0	375	272	0	275	56	24	15	2.6	18	5.6	0.3	0.44	30	—		Cherry Creek
3N/57E-16d	—	6-80	11	6.7	430	327	0	—	67	24	17	3.4	21	10	0.3	0.9	32	—		Spring
3N/58E-16a	Uhalde	6-80	8	7.1	365	249	0	—	34	30	10	4.1	15	6.1	0.3	1.4	32	—		well
2N/58E-14c	Civa Corp.	6-80	—	7.4	430	205	0	—	44	10	22	2	28	8.5	0.1	2.7	14	—		Heizer Well
2N/59E-17a	—	6-80	19	8.4	445	273	0	234	40	25	15	2.6	21	7.1	0.3	0.28	28	—		watergap
1N/57E-20	—	6-80	12	7.0	660	390	0	—	111	20	43	3.9	78	18	1.3	0.0	66	—		spring
1N/57E-20	Gold Crk. Crp	6-80	—	7.6	445	386	0	—	100	17	30	3	55	15	0.7	3.4	23	—		Freiburg Mine Well
1S/57E-2bb	Uhalde	6-80	—	8.0	305	205	0	—	11	3.4	90	4	21	8.5	0.8	9.4	23	—		South Uhalde Well

NOTE: SAMPLES FOR WATER QUALITY ANALYSIS COLLECTED BY FUGRO NATIONAL EXCEPT WHERE NOTED. ALL ANALYSIS USED IN mg/l EXCEPT WHERE NOTED. FUGRO NATIONAL ANALYSIS FOR DISSOLVED SOLIDS CALCULATED USING THE RESIDUE - ON - EVAPORATION AT 180 C METHOD. OTHER AUTHORS MAY USE DIFFERENT METHODS. NEVADA LOCATIONS BASED ON MT. DIABLO BASELINE AND UTAH LOCATIONS BASED ON SALT LAKE BASELINE AND MERIDIAN.

WATER QUALITY ANALYSES
GARDEN VALLEY, NEVADA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE — BMO

TABLE C1-4

FUGRO NATIONAL, INC.

SAMPLE LOCATION	OWNER OR WATER USER	DATE OF COLLECTION (mo - yr)	FIELD DETERMINATIONS					DISSOLVED SOLIDS (see note)	CALCIUM (Ca)	MAGNESIUM (Mg)	SODIUM (Na)	POTASSIUM (K)	SULFATE (SO_4)	CHLORIDE (Cl)	FLUORIDE (F)	NITRATE (as N)	SILICA (SiO_2)	TRITIUM (pCi/liter)	REFERENCES	REMARKS
			TEMPERATURE °C	pH	SPECIFIC CONDUCTANCE (µmhos/cm @ 25 C)	BICARBONATE (HCO_3)	CARBONATE (CO_3)													
10N/66E-31a1	—	8-63	15	7.8	322	189	0	203	54	5.7	7.4	1.9	6.4	9.6	0	1.2	27	—	1	Stock Well
9N/65E-4c1	—	8-63	20	8.0	181	103	0	115	30	3.4	3.0	1.0	5.0	3.0	0	0.6	13	—	1	Geyser Spring
3N/66E-2dd	—	10-63	—	7.8	374	129	—	—	42	9.0	—	—	—	30	—	—	—	—	2	21-mile Corral

References:

1. Rush and Eakin, 1963
2. Rush, 1964

NOTE: SAMPLES FOR WATER QUALITY ANALYSIS COLLECTED BY FUGRO NATIONAL EXCEPT WHERE NOTED. ALL ANALYSIS USED IN mg/l EXCEPT WHERE NOTED. FUGRO NATIONAL ANALYSIS FOR DISSOLVED SOLIDS CALCULATED USING THE RESIDUE - ON - EVAPORATION AT 180 C METHOD. OTHER AUTHORS MAY USE DIFFERENT METHODS. NEVADA LOCATIONS BASED ON MT. DIABLO BASELINE AND UTAH LOCATIONS BASED ON SALT LAKE BASELINE AND MERIDIAN.

WATER QUALITY ANALYSES
LAKE VALLEY, NEVADA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE — BMO

TABLE C1-5

FUGRO NATIONAL, INC.

SAMPLE LOCATION	OWNER OR WATER USER	DATE OF COLLECTION (mo - yr)	FIELD DETERMINATIONS: TEMPERATURE C	FIELD DETERMINATIONS: pH	FIELD DETERMINATIONS: SPECIFIC CONDUCTANCE (µmhos/cm @ 25 C)	FIELD DETERMINATIONS: BICARBONATE (HCO_3)	FIELD DETERMINATIONS: CARBONATE (CO_3)	DISSOLVED SOLIDS (see note)	CALCIUM (Ca)	MAGNESIUM (Mg)	SODIUM (Na)	POTASSIUM (K)	SULFATE (SO_4)	CHLORIDE (Cl)	FLUORIDE (F)	NITRATE (as N)	SILICA (SiO_2)	TRITIUM (pCi/liter)	REFERENCES	REMARKS
5N/64E-7ddd	—	5-80	14.5	8.0	530	364	0	—	53	17	17	1.2	40	67	0.3	1.0	26	—		Big Mud Sp.
5N/65E-10cab	—	5-80	12	7.4	465	346	0	—	60	16	26	0.4	27	13	0.2	0.3	58	—		Horse Corral Spring
5N/65E-32ad	—	5-80	11.5	6.8	540	259	0	—	53	11	180	3.9	17	29	0.2	1.0	74	—		Malloy Spring

NOTE: SAMPLES FOR WATER QUALITY ANALYSIS COLLECTED BY FUGRO NATIONAL EXCEPT WHERE NOTED. ALL ANALYSIS USED IN mg/l EXCEPT WHERE NOTED. FUGRO NATIONAL ANALYSIS FOR DISSOLVED SOLIDS CALCULATED USING THE RESIDUE - ON - EVAPORATION AT 180 C METHOD. OTHER AUTHORS MAY USE DIFFERENT METHODS. NEVADA LOCATIONS BASED ON MT. DIABLO BASELINE AND UTAH LOCATIONS BASED ON SALT LAKE BASELINE AND MERIDIAN.

WATER QUALITY ANALYSES
MULESHOE VALLEY, NEVADA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE — BMO

TABLE C1-6

FUGRO NATIONAL, INC.

SAMPLE LOCATION	OWNER OR WATER USER	DATE OF COLLECTION (mo-yr)	FIELD DETERMINATIONS: TEMPERATURE °C	FIELD DETERMINATIONS: pH	FIELD DETERMINATIONS: SPECIFIC CONDUCTANCE (µmhos/cm @ 25°C)	FIELD DETERMINATIONS: BICARBONATE (HCO_3)	FIELD DETERMINATIONS: CARBONATE (CO_3)	DISSOLVED SOLIDS (see note)	CALCIUM (Ca)	MAGNESIUM (Mg)	SODIUM (Na)	POTASSIUM (K)	SULFATE (SO_4)	CHLORIDE (Cl)	FLUORIDE (F)	NITRATE (as N)	SILICA (SiO_2)	TRITIUM (pCi/liter)	REFERENCES	REMARKS
3S/62E-25ab	—	5-80	15	7.0	190	151	0	—	28	7.6	13	5	12	12	0.2	0.6	23	<200		Pahroc Spring

NOTE: SAMPLES FOR WATER QUALITY ANALYSIS COLLECTED BY FUGRO NATIONAL EXCEPT WHERE NOTED. ALL ANALYSIS USED IN mg/l EXCEPT WHERE NOTED. FUGRO NATIONAL ANALYSIS FOR DISSOLVED SOLIDS CALCULATED USING THE RESIDUE-ON-EVAPORATION AT 180 C METHOD. OTHER AUTHORS MAY USE DIFFERENT METHODS. NEVADA LOCATIONS BASED ON MT. DIABLO BASELINE AND UTAH LOCATIONS BASED ON SALT LAKE BASELINE AND MERIDIAN.

WATER QUALITY ANALYSES
PAHROC VALLEY, NEVADA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE — BMO

TABLE C1-7

FUGRO NATIONAL, INC.

SAMPLE LOCATION	OWNER OR WATER USER	DATE OF COLLECTION (mo - yr)	FIELD DETERMINATIONS					DISSOLVED SOLIDS (see note)	CALCIUM (Ca)	MAGNESIUM (Mg)	SODIUM (Na)	POTASSIUM (K)	SULFATE (SO_4)	CHLORIDE (Cl)	FLUORIDE (F)	NITRATE (as N)	SILICA (SiO_2)	TRITIUM (pCi/liter)	REFERENCES	REMARKS
			TEMPERATURE °C	pH	SPECIFIC CONDUCTANCE (µmhos/cm @ 25°C)	BICARBONATE (HCO_3)	CARBONATE (CO_3)													
2N/55E-19cdd	—	6-80	10	6.2	260	139	0	222	32	6.7	29	3.9	24	6	0.7	0.30	52	—		Quinn Cyn Sp
1N/56E-9daa	—	6-80	13	6.4	625	288	0	—	64	12	80	6.9	73	48	1.0	1.3	50	—		McCutcher Sp
1S/55E-22abd	—	6-80	22	7.3	285	134	0	206	25	4.0	28	5.7	17	8.3	0.7	1.12	72	—		Smith Well
1S/56E-12adb	—	6-80	12	6.5	480	307	0	326	70	30	9.6	1.5	44	4.8	0.3	0.67	20	—		Wild Horse Sp
2S/55E-26dda	—	10-71	30	8	609	357	0	—	36	22	67*	—	25	5	—	—	—	—	1	Sand Spring
2S/57E-28ddb	—	6-80	14	6.6	690	405	0	—	96	27	48	4.0	40	29	0.6	3.3	50	—		Seep Spring

References:

1. Van Denburgh and Rush, 1973

* Sodium plus potassium.

NOTE: SAMPLES FOR WATER QUALITY ANALYSIS COLLECTED BY FUGRO NATIONAL EXCEPT WHERE NOTED. ALL ANALYSIS USED IN mg/l EXCEPT WHERE NOTED. FUGRO NATIONAL ANALYSIS FOR DISSOLVED SOLIDS CALCULATED USING THE RESIDUE - ON - EVAPORATION AT 180 C METHOD. OTHER AUTHORS MAY USE DIFFERENT METHODS. NEVADA LOCATIONS BASED ON MT. DIABLO BASELINE AND UTAH LOCATIONS BASED ON SALT LAKE BASELINE AND MERIDIAN.

WATER QUALITY ANALYSES
PENOYER VALLEY, NEVADA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE — BMO

TABLE C1-8

FUGRO NATIONAL, INC.

SAMPLE LOCATION	OWNER OR WATER USER	DATE OF COLLECTION (mo/yr)	FIELD DETERMINATIONS: TEMPERATURE °C	pH	SPECIFIC CONDUCTANCE (µmhos/cm @ 25°C)	BICARBONATE (HCO_3)	CARBONATE (CO_3)	DISSOLVED SOLIDS (see note)	CALCIUM (Ca)	MAGNESIUM (Mg)	SODIUM (Na)	POTASSIUM (K)	SULFATE (SO_4)	CHLORIDE (Cl)	FLUORIDE (F)	NITRATE (as N)	SILICA (SiO_2)	TRITIUM (pCi/liter)	REFERENCES	REMARKS
23N/66E-31a1	—	6-50	32	—	309	141	0	—	24	7.4	34	—	22	16	—	—	—	—	1	
19N/67E-13aa	—	6-80	12	7.5	460	200	0	288	39	17	36	2.9	57	13	0.4	0.7	34	—		
18N/66E-25a1	—	6-50	12	—	112	63	0	—	10	3.6	12*	—	3.9	5	—	—	—	—	1	
18N/67E-1c1	—	7-64	12	8.1	975	264	0	—	47	26	122*	—	148	85	—	—	—	—	1	
17N/66E-3ab	—	6-80	9	7.2	28	12	0	—	2.2	1.7	2.4	0.4	2.4	2.8	0.09	0.04	8.0	—		McCoy Creek
17N/66E-15ac	—	6-80	6	7.5	23	8	0	3	2.0	0.7	1.0	0.4	0	1.0	0.2	0.07	5.0	—		Taft Creek
16N/66E-13a1	—	7-64	13	7.8	287	172	0	—	38	7.8	15*	—	12	4.7	—	—	—	—	1	spring
16N/66E-34ba	Cleve Rch	6-80	12	7.6	84	44	0	35	13	3.2	1.8	0.4	6.4	.9	0.04	0.03	8.0	—		Cleve Creek
16N/67E-3aa	Rogers Rch	6-80	16	7.3	580	360	0	285	56	27	20	1.5	0	14	0.2	0.11	20	—		
16N/67E-27d	—	7-64	16	8.0	911	521	0	—	58	30	105*	—	36	23	—	—	—	—	1	
15N/66E-21ac	Bastian Rch	6-80	11	8.2	315	204	0	147	53	7.0	3.7	0.5	5.4	2.2	0.04	0.30	8.0	—		Bastian Spring
15N/68E-8b	—	7-64	12	8.0	626	346	0	—	65	33	21	—	26	23	—	—	—	—	1	
14N/66-24a1	—	7-64	12	7.8	499	220	0	—	48	26	22*	—	63	19	—	—	—	—	1	
14N/67-16dd	—	6-80	13	7.4	[illegible]	176	0	236	27	11	43	2.7	46	26	0.4	0.53	23	—		
13N/67E-15d1	—	6-50	18	—	161	84	0	—	17	3.3	14*	—	7.0	7	—	—	—	—	1	
13N/67E-18d	—	7-64	12	8.2	395	204	0	—	39	22	12*	—	34	8	—	—	—	—	1	
13N/67E-33d	—	7-64	14	8.5	750	239	16	—	61	14	82*	—	52	80	—	—	—	—	1	
13N/67E-35d	—	7-64	23	—	158	88	0	—	18	1.0	16*	—	5.8	3.5	—	—	—	—	1	
13N/68E-17cb	—	6-80	10	7.5	48	28	0	—	4.6	2.6	2.5	0.4	4.4	1.8	0.1	0.05	8.5	—		Pine Creek
13N/68E-32db	—	6-80	6.5	7.2	37	20	0	9	3.2	1.7	1.8	0.5	2.4	1.2	0.4	—	9.5	—		Williams Creek
12N/67E-2a	—	6-80	23	7.9	114	88	0	—	20	2.7	9.2	1.1	4.4	2.6	0.04	0.22	22	—		flowing well
11N/66E-35db	—	6-80	12	7.7	335	220	0	160	30	21	7.9	1.3	12	5.5	0.4	0.8	16	—		flowing well
11N/67E-1c1	—	—	12	—	374	220	0	—	58	12	8.2*	—	14	7	—	—	—	—	1	
11N/67E-1bc	Shoshone Rch	6-80	11	7.5	305	196	0	144	47	10	3.8	0.7	6.2	1.6	0.2	0.5	11	—		
11N/67E-4c	—	6-80	9	7.6	305	200	0	—	48	8.8	1.4	0.4	4.2	1.1	0.1	0.07	4	—		Shallow Spring
11N/68E-31cd	—	6-80	14	7.6	440	196	0	—	42	27	6.8	2.0	11	18	0.1	8.2	22	—		
9N/67E-27a1	—	7-69	21	7.9	236	122	0	—	24	6.8	18*	—	11	11	—	—	—	—	1	spring

*Sodium plus potassium.

References:

1. Rush and Kazmi, 1965

NOTE: SAMPLES FOR WATER QUALITY ANALYSIS COLLECTED BY FUGRO NATIONAL EXCEPT WHERE NOTED. ALL ANALYSIS USED IN mg/l EXCEPT WHERE NOTED. FUGRO NATIONAL ANALYSIS FOR DISSOLVED SOLIDS CALCULATED USING THE RESIDUE - ON - EVAPORATION AT 180 C METHOD. OTHER AUTHORS MAY USE DIFFERENT METHODS. NEVADA LOCATIONS BASED ON MT. DIABLO BASELINE AND UTAH LOCATIONS BASED ON SALT LAKE BASELINE AND MERIDIAN.

WATER QUALITY ANALYSES
SPRING VALLEY, NEVADA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE — BMO

TABLE C1-9

FUGRO NATIONAL, INC.

APPENDIX D1.0

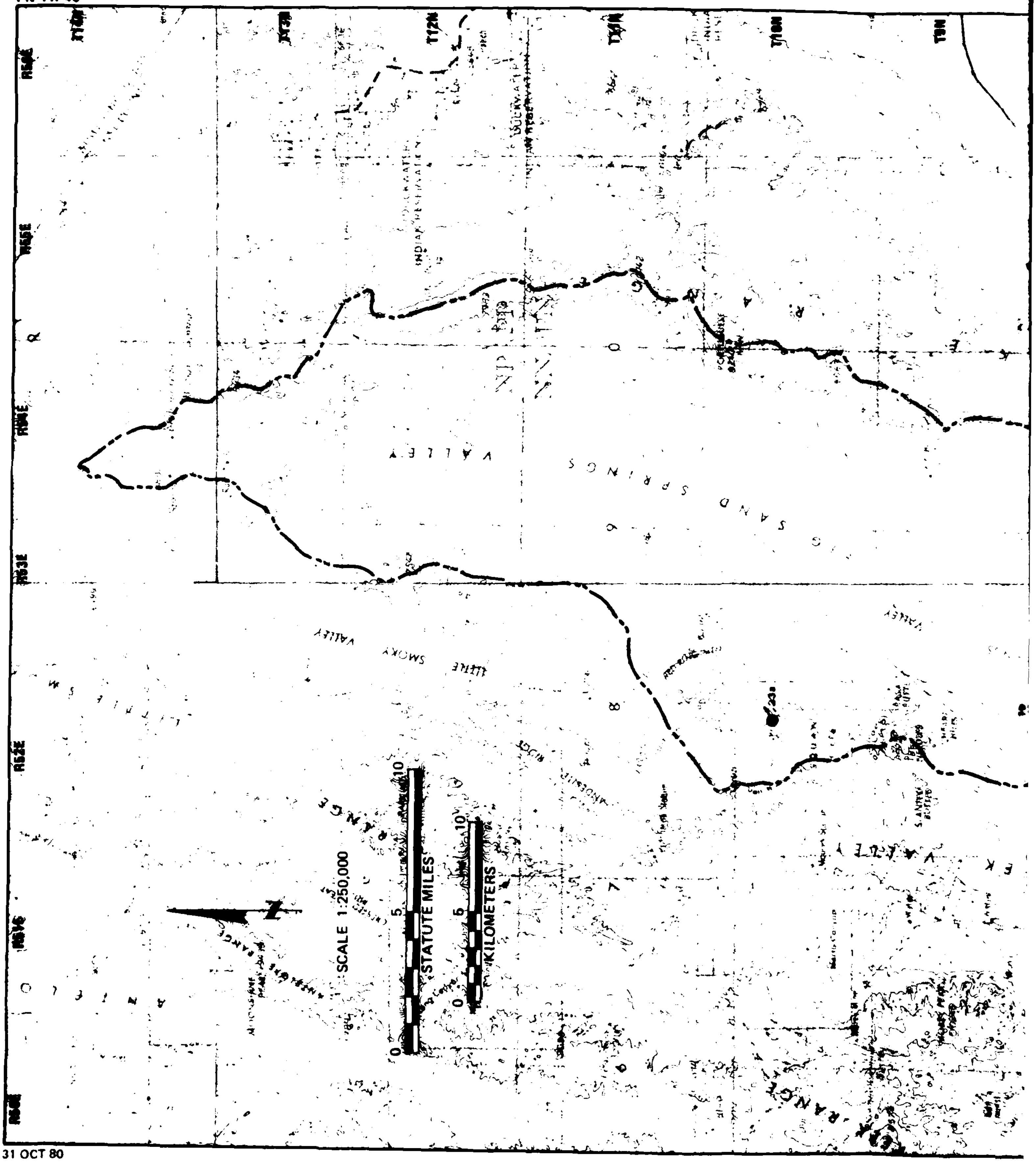
WATER-QUALITY DRAWINGS

APPENDIX D

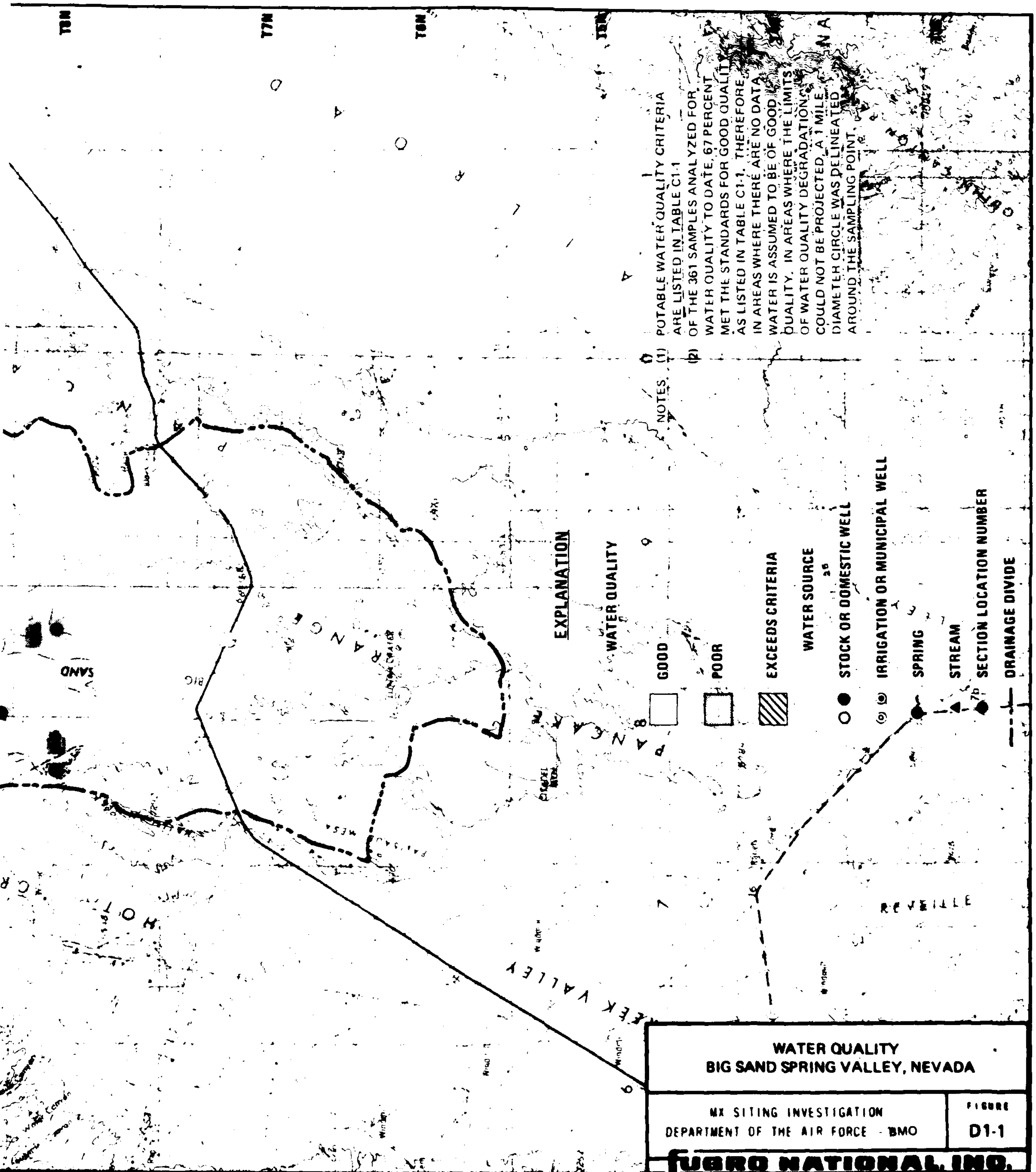
TABLE OF CONTENTS

D1.0 WATER QUALITY DRAWINGS

FN-TR-40



31 OCT 80



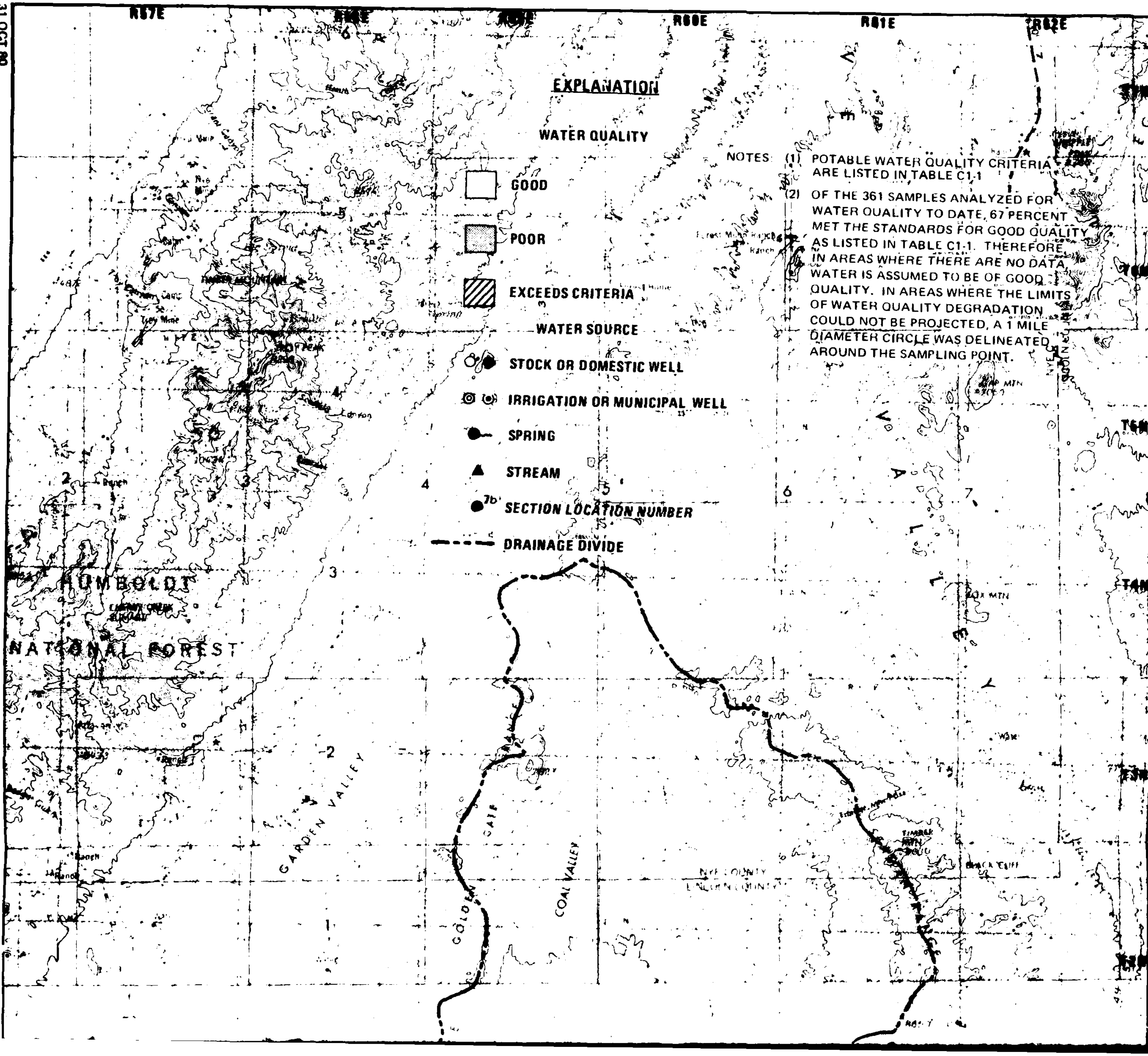
WATER QUALITY
BIG SAND SPRING VALLEY, NEVADA

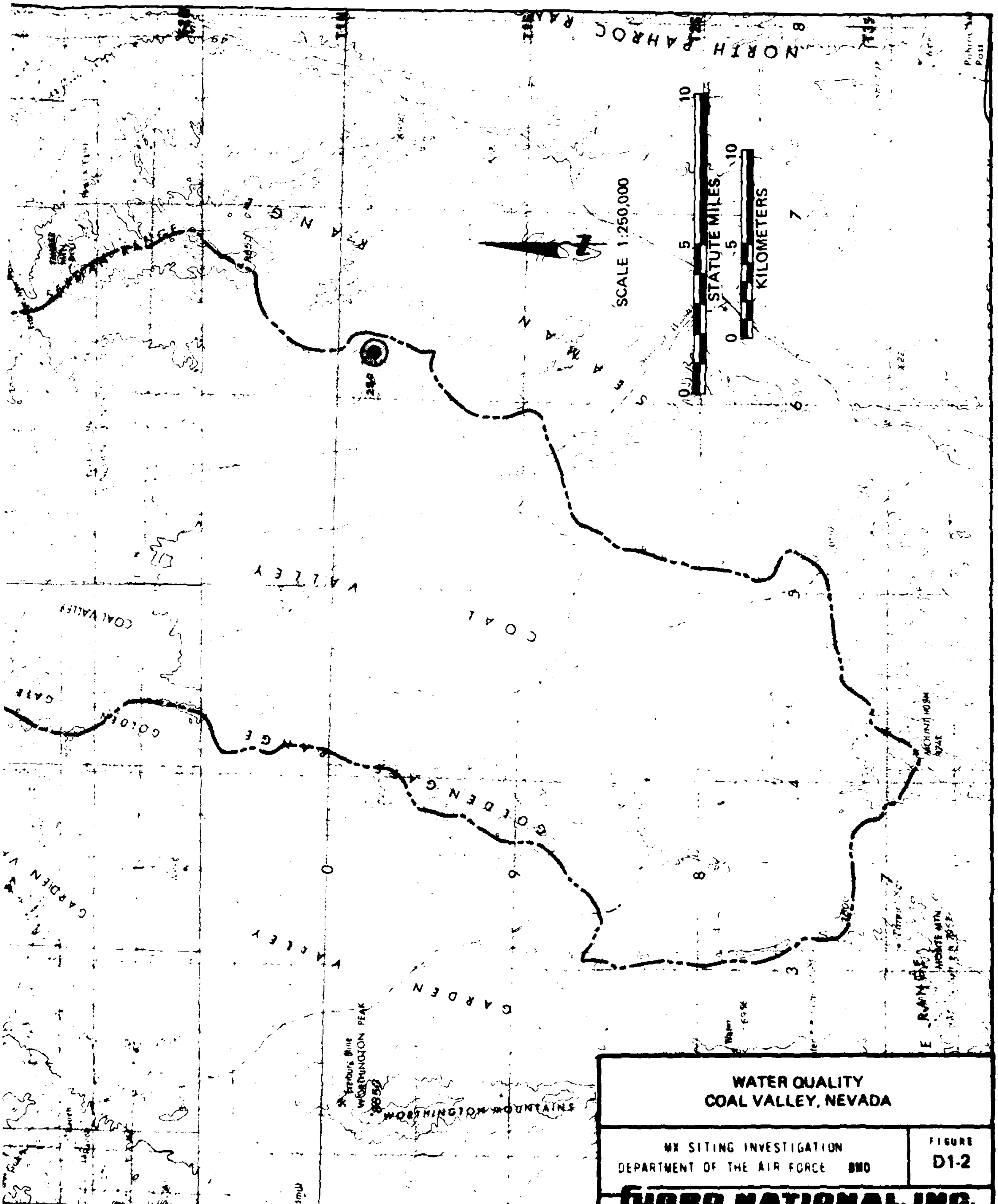
MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - BMO

FIGURE D1-1

FUGRO NATIONAL, INC.

2


R57E
R60E
R61E
R62E
EXPLANATION
WATER QUALITY
GOOD
POOR
EXCEEDS CRITERIA
WATER SOURCE
STOCK OR DOMESTIC WELL
IRRIGATION OR MUNICIPAL WELL
SPRING
STREAM
7b SECTION LOCATION NUMBER
DRAINAGE DIVIDE
NOTES: (1) POTABLE WATER QUALITY CRITERIA ARE LISTED IN TABLE C1-1
(2) OF THE 361 SAMPLES ANALYZED FOR WATER QUALITY TO DATE, 67 PERCENT MET THE STANDARDS FOR GOOD QUALITY AS LISTED IN TABLE C1-1. THEREFORE, IN AREAS WHERE THERE ARE NO DATA, WATER IS ASSUMED TO BE OF GOOD QUALITY. IN AREAS WHERE THE LIMITS OF WATER QUALITY DEGRADATION COULD NOT BE PROJECTED, A 1 MILE DIAMETER CIRCLE WAS DELINEATED AROUND THE SAMPLING POINT.
HUMBOLDT
NATIONAL FOREST
GARDEN VALLEY
COAL VALLEY
GOLDEN GATE
NYE COUNTY
LINCOLN COUNTY
FOX MTN
BLACK CLIFF

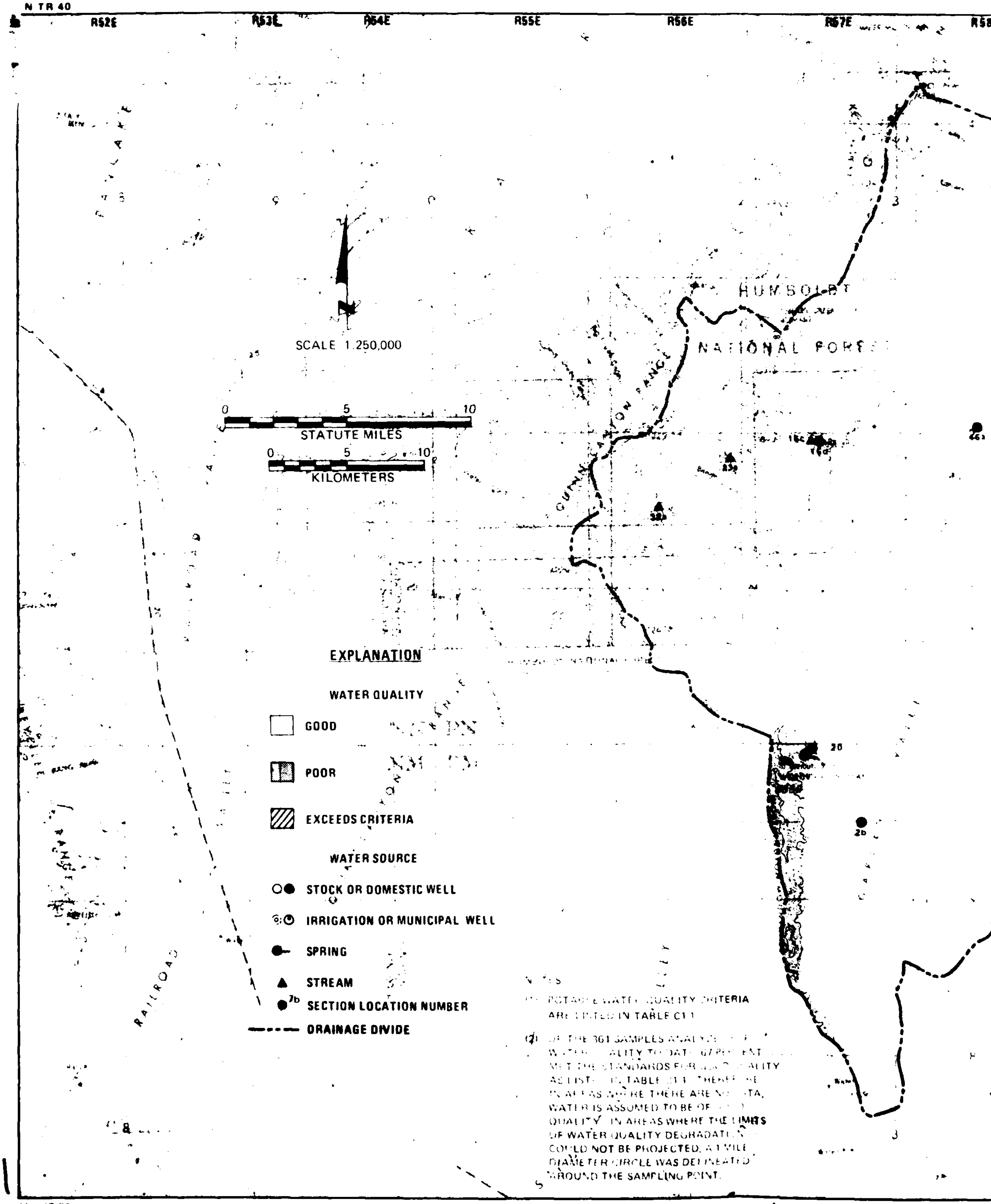


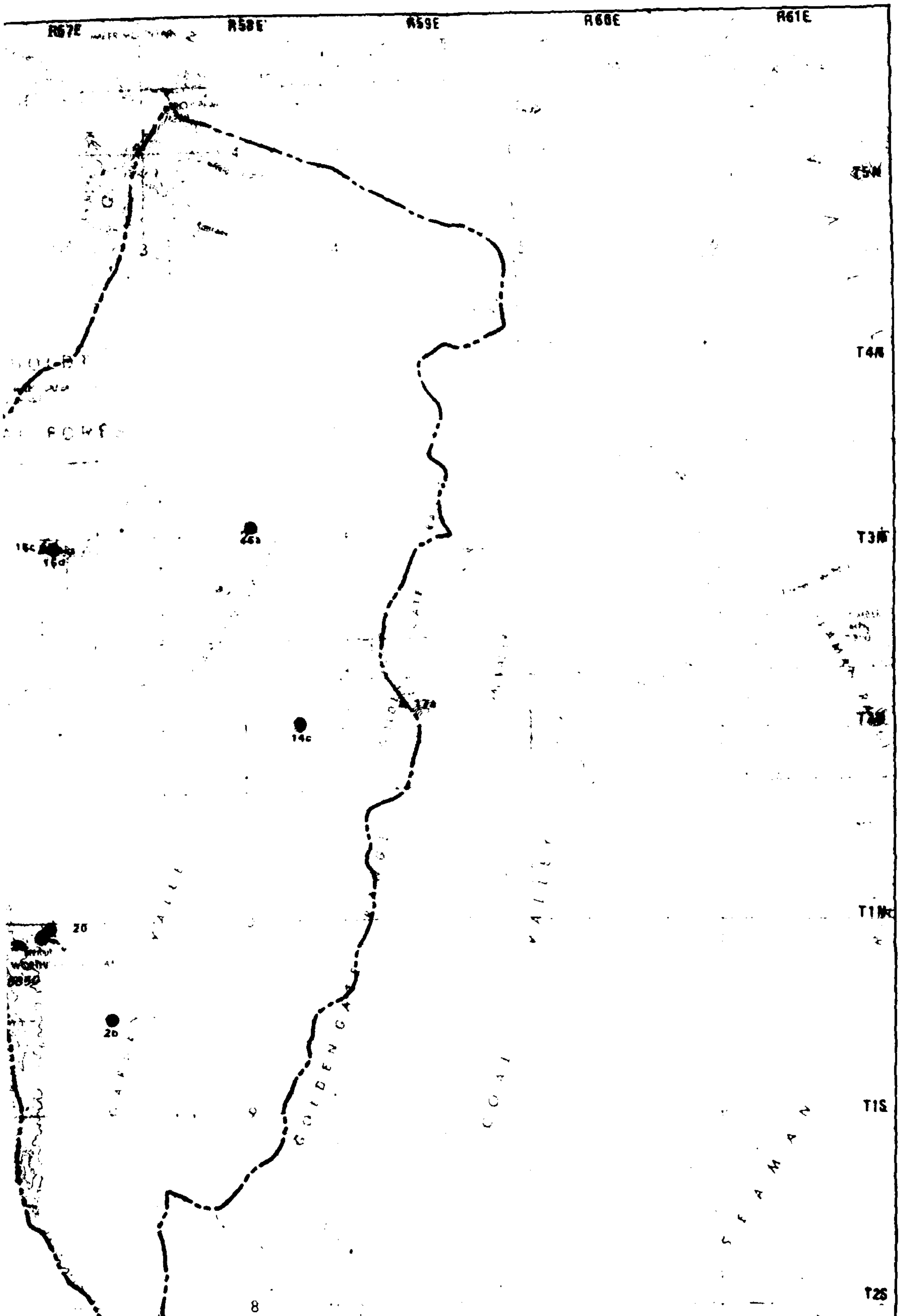
WATER QUALITY
COAL VALLEY, NEVADA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE BMO

FIGURE
D1-2

FUGRO NATIONAL, INC.


R52E
R53E
R54E
R55E
R56E
R57E
HUMBOLDT
NATIONAL FOREST
QUINN CANYON RANGE
RAILROAD
SCALE 1:250,000
0 5 10
STATUTE MILES
0 5 10
KILOMETERS
EXPLANATION
WATER QUALITY
GOOD
POOR
EXCEEDS CRITERIA
WATER SOURCE
STOCK OR DOMESTIC WELL
IRRIGATION OR MUNICIPAL WELL
SPRING
STREAM
SECTION LOCATION NUMBER
DRAINAGE DIVIDE
20
2b
WATER IS ASSUMED TO BE OF
QUALITY. IN AREAS WHERE THE LIMITS
OF WATER QUALITY DEGRADATION
COULD NOT BE PROJECTED, A 1 MILE
DIAMETER CIRCLE WAS DELINEATED
AROUND THE SAMPLING POINT.

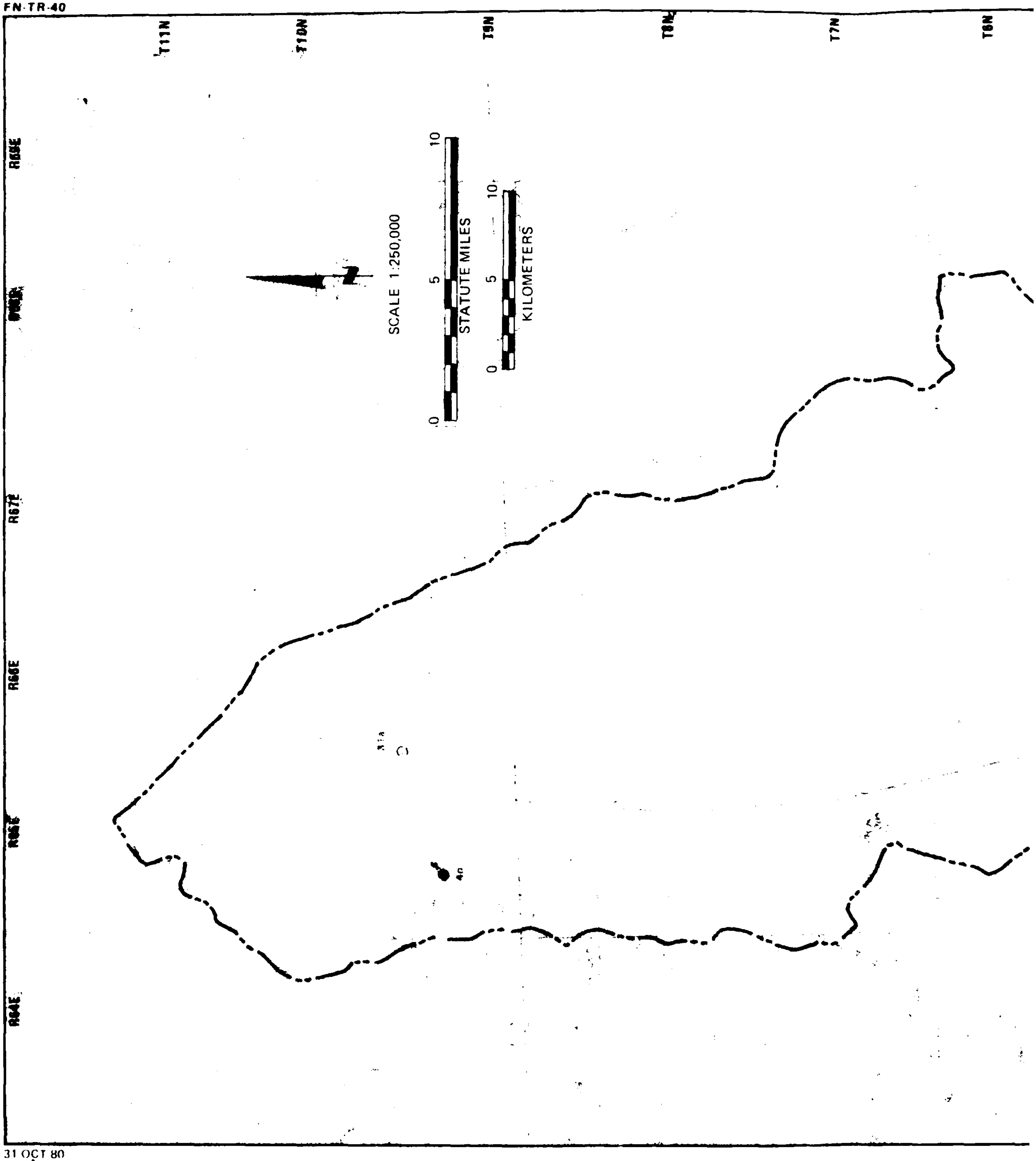


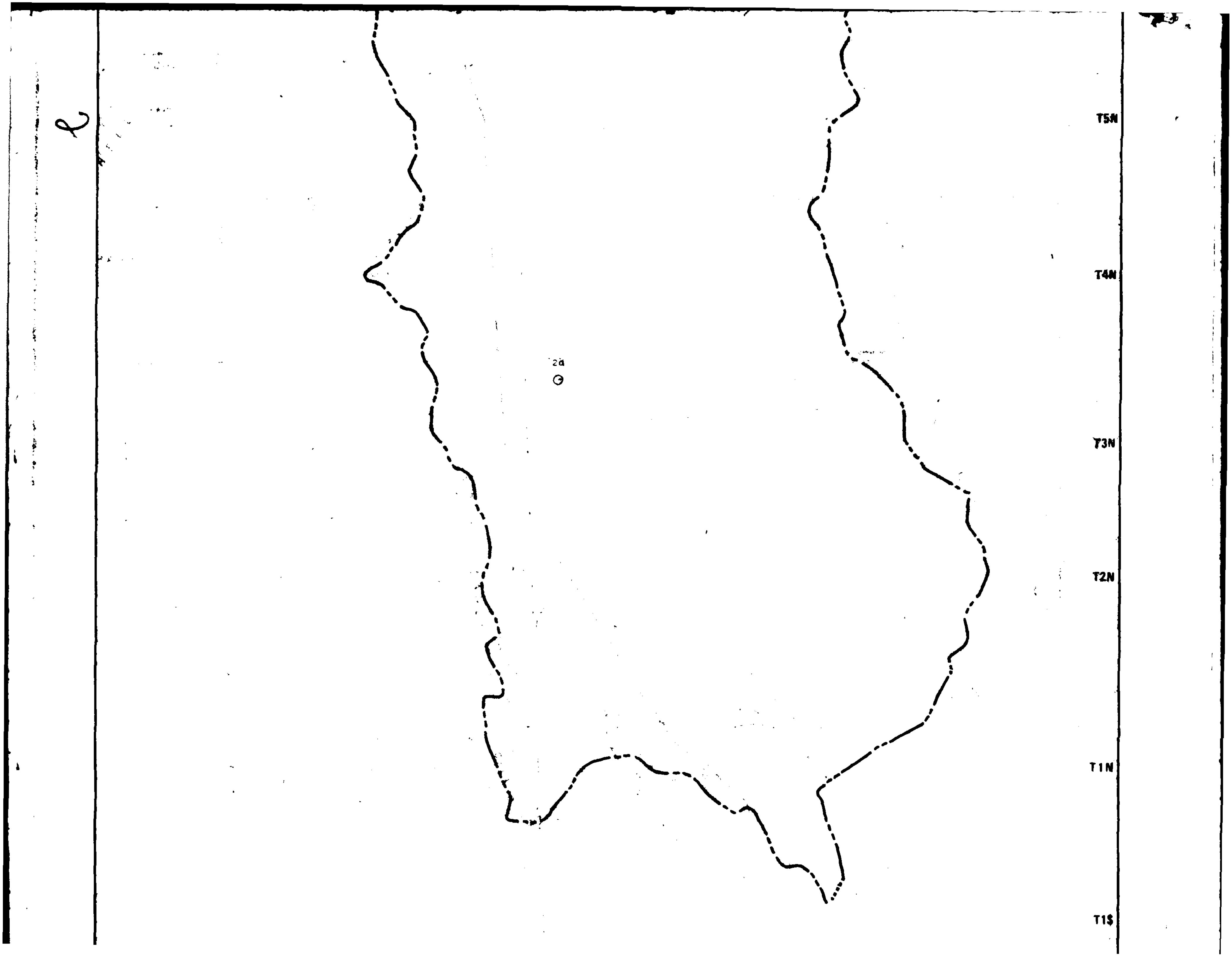
WATER QUALITY
GARDEN VALLEY, NEVADA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - BMO

FIGURE D1-3

FUGRO NATIONAL, INC.


T11N
T10N
T9N
T8N
T7N
T6N
R69E
R67E
R66E
R65E
R64E
SCALE 1:250,000
0 5 10
STATUTE MILES
0 5 10
KILOMETERS



2a
T5N
T4N
T3N
T2N
T1N
T1S

EXPLANATION

WATER QUALITY

- GOOD
- POOR
- EXCEEDS CRITERIA

WATER SOURCE

- STOCK OR DOMESTIC WELL
- IRRIGATION OR MUNICIPAL WELL
- SPRING
- STREAM
- $\bullet^{7b}$ SECTION LOCATION NUMBER
- DRAINAGE DIVIDE

NOTES: (1) POTABLE WATER QUALITY CRITERIA ARE LISTED IN TABLE C1.1

(2) OF THE [illegible]61 SAMPLES ANALYZED FOR WATER QUALITY TO DATE, 67 PERCENT MET THE STANDARDS FOR GOOD QUALITY AS LISTED IN TABLE C1.1. THEREFORE, IN AREAS WHERE THERE ARE NO DATA, WATER IS ASSUMED TO BE OF GOOD QUALITY. IN AREAS WHERE THE LIMITS OF WATER QUALITY DEGRADATION COULD NOT BE PROJECTED, A 1 MILE DIAMETER CIRCLE WAS DELINEATED AROUND THE SAMPLING POINT

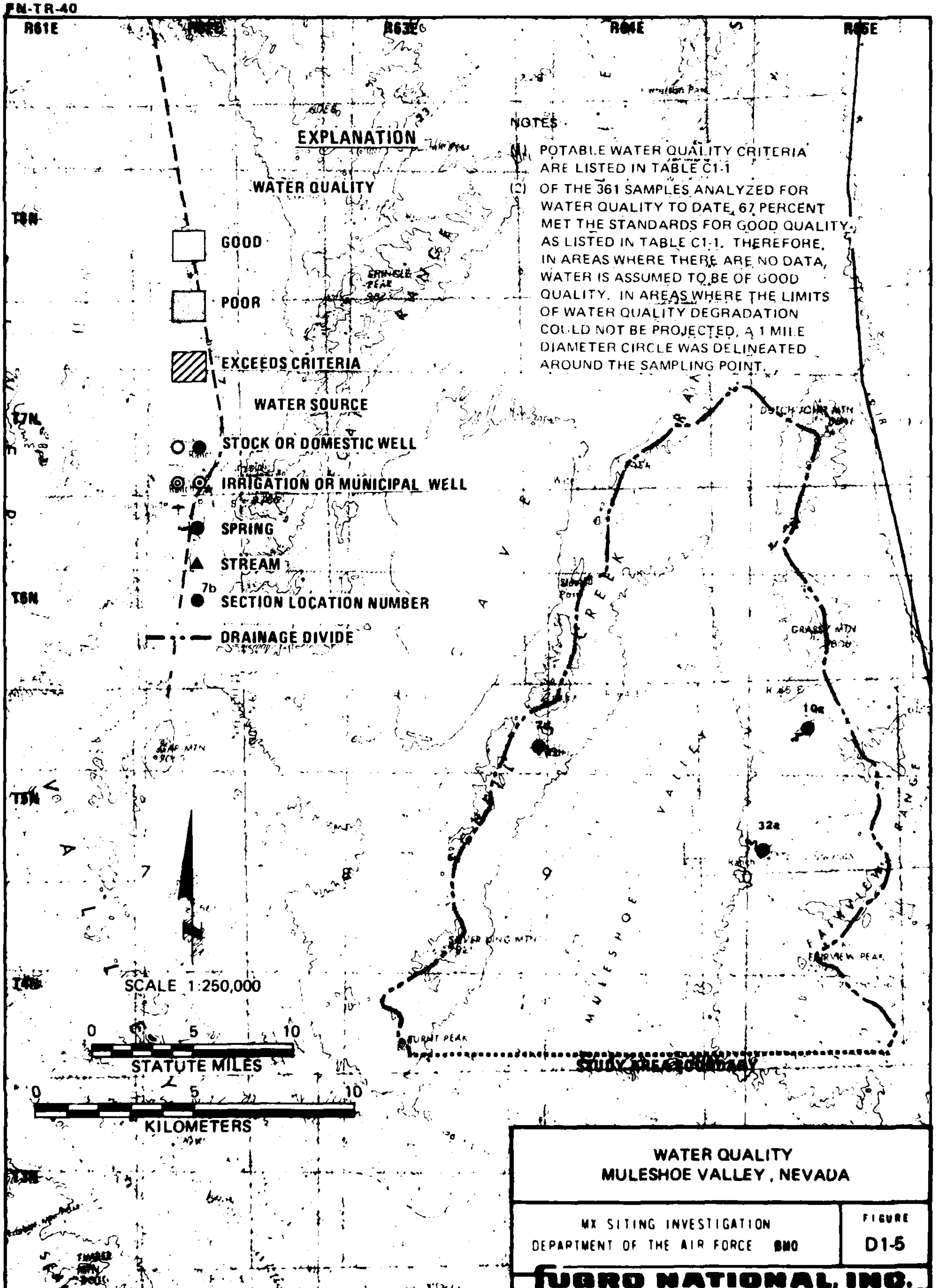
WATER QUALITY
LAKE VALLEY, NEVADA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE — BMO

FIGURE D1-4

FUGRO NATIONAL, INC.

3


R61E
R63E
R64E
R65E
T8N
T7N
T6N
T5N
EXPLANATION
WATER QUALITY
GOOD
POOR
EXCEEDS CRITERIA
WATER SOURCE
STOCK OR DOMESTIC WELL
IRRIGATION OR MUNICIPAL WELL
SPRING
STREAM
7b
SECTION LOCATION NUMBER
DRAINAGE DIVIDE
NOTES
(1) POTABLE WATER QUALITY CRITERIA ARE LISTED IN TABLE C1-1
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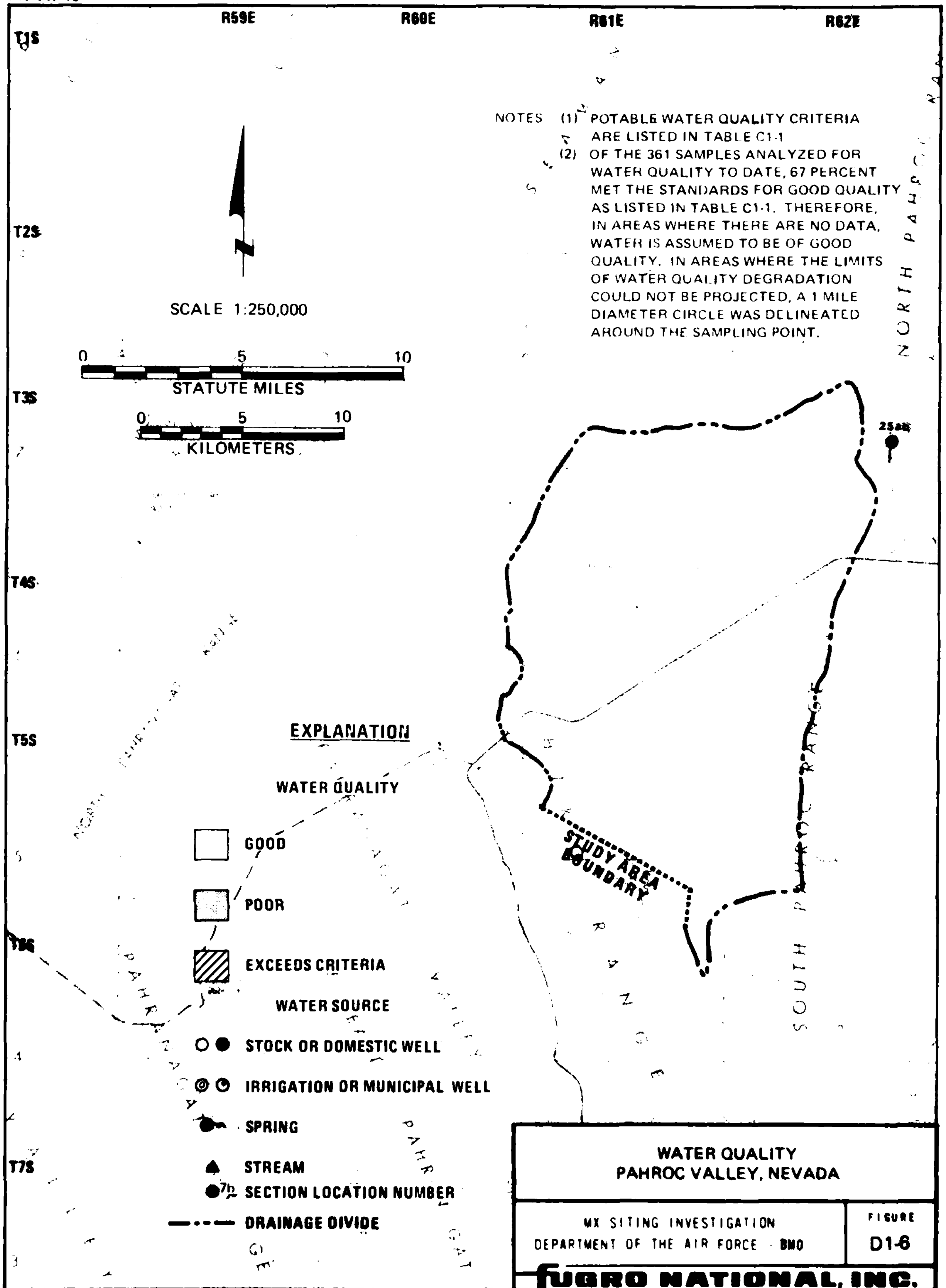
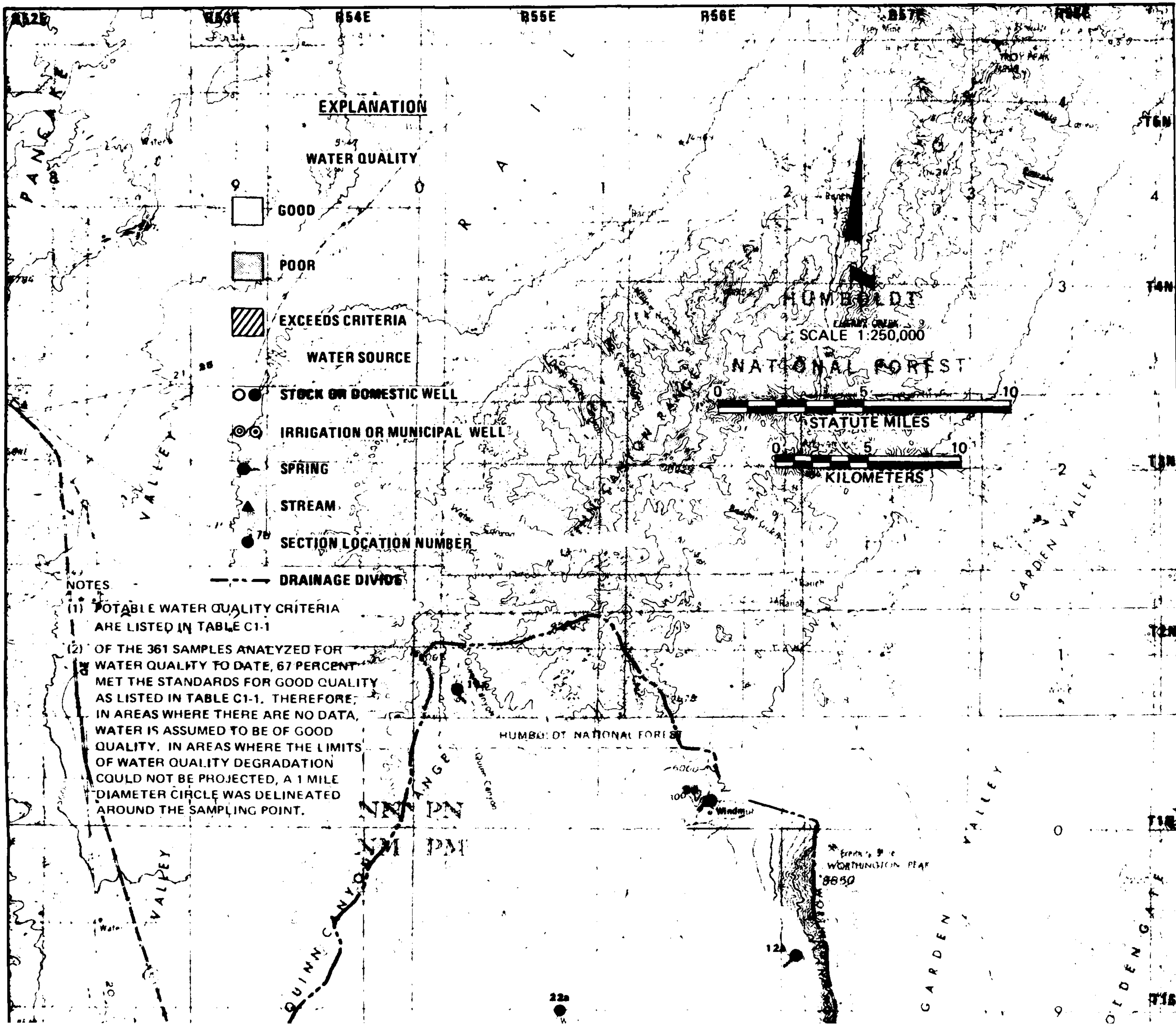
DUTCH JOHN MTN
GRASSY MTN
10a
32a
7
8
9
MULESHOE VALLEY
FAIRVIEW RANGE
FAIRVIEW PEAK
SILVER KING MTN
BURNT PEAK
STUDY AREA BOUNDARY
SCALE 1:250,000
0 5 10
STATUTE MILES
0 5 10
KILOMETERS
WATER QUALITY
MULESHOE VALLEY, NEVADA
MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE BMO
FIGURE
D1-5
FUGRO NATIONAL, INC.

31 OCT 80

FN-TR-40



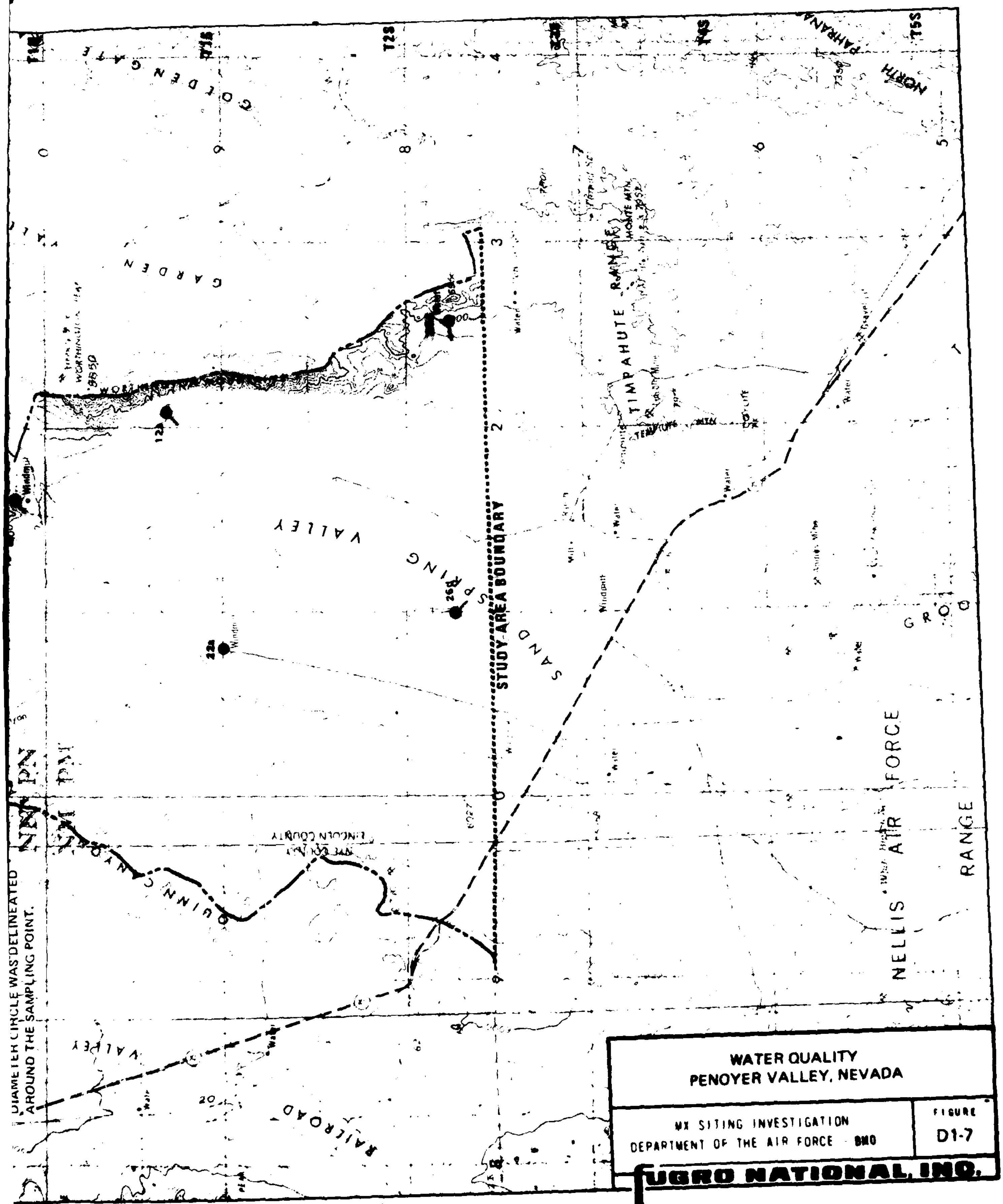
31 OCT 80



NOTES

(1) POTABLE WATER QUALITY CRITERIA ARE LISTED IN TABLE C1-1

(2) OF THE 361 SAMPLES ANALYZED FOR WATER QUALITY TO DATE, 67 PERCENT MET THE STANDARDS FOR GOOD QUALITY AS LISTED IN TABLE C1-1. THEREFORE, IN AREAS WHERE THERE ARE NO DATA, WATER IS ASSUMED TO BE OF GOOD QUALITY. IN AREAS WHERE THE LIMITS OF WATER QUALITY DEGRADATION COULD NOT BE PROJECTED, A 1 MILE DIAMETER CIRCLE WAS DELINEATED AROUND THE SAMPLING POINT.



DIAMETER CIRCLE WAS DELINEATED AROUND THE SAMPLING POINT.

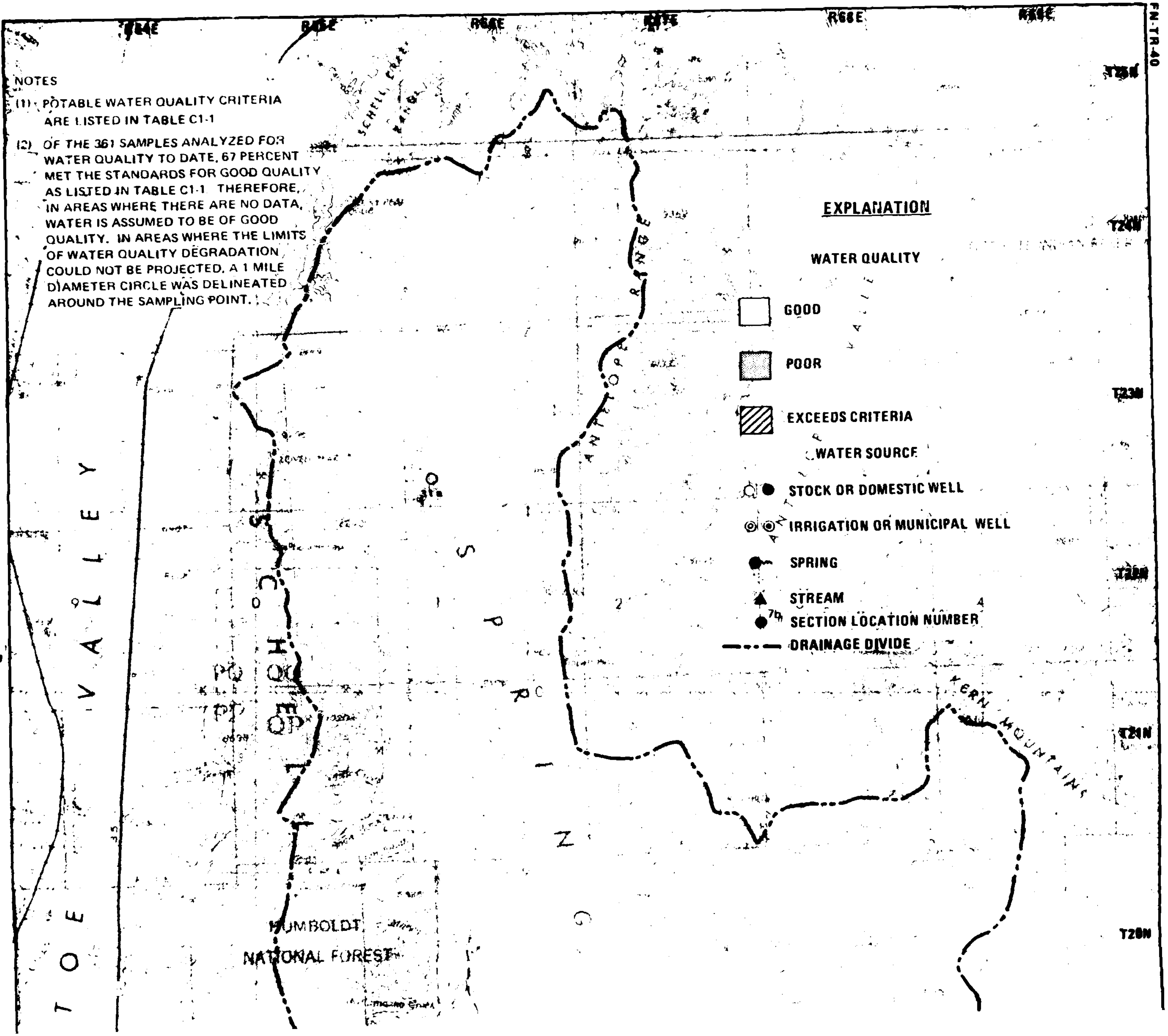
WATER QUALITY
PENOYER VALLEY, NEVADA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - BMO

FIGURE D1-7

FUGRO NATIONAL, INC.

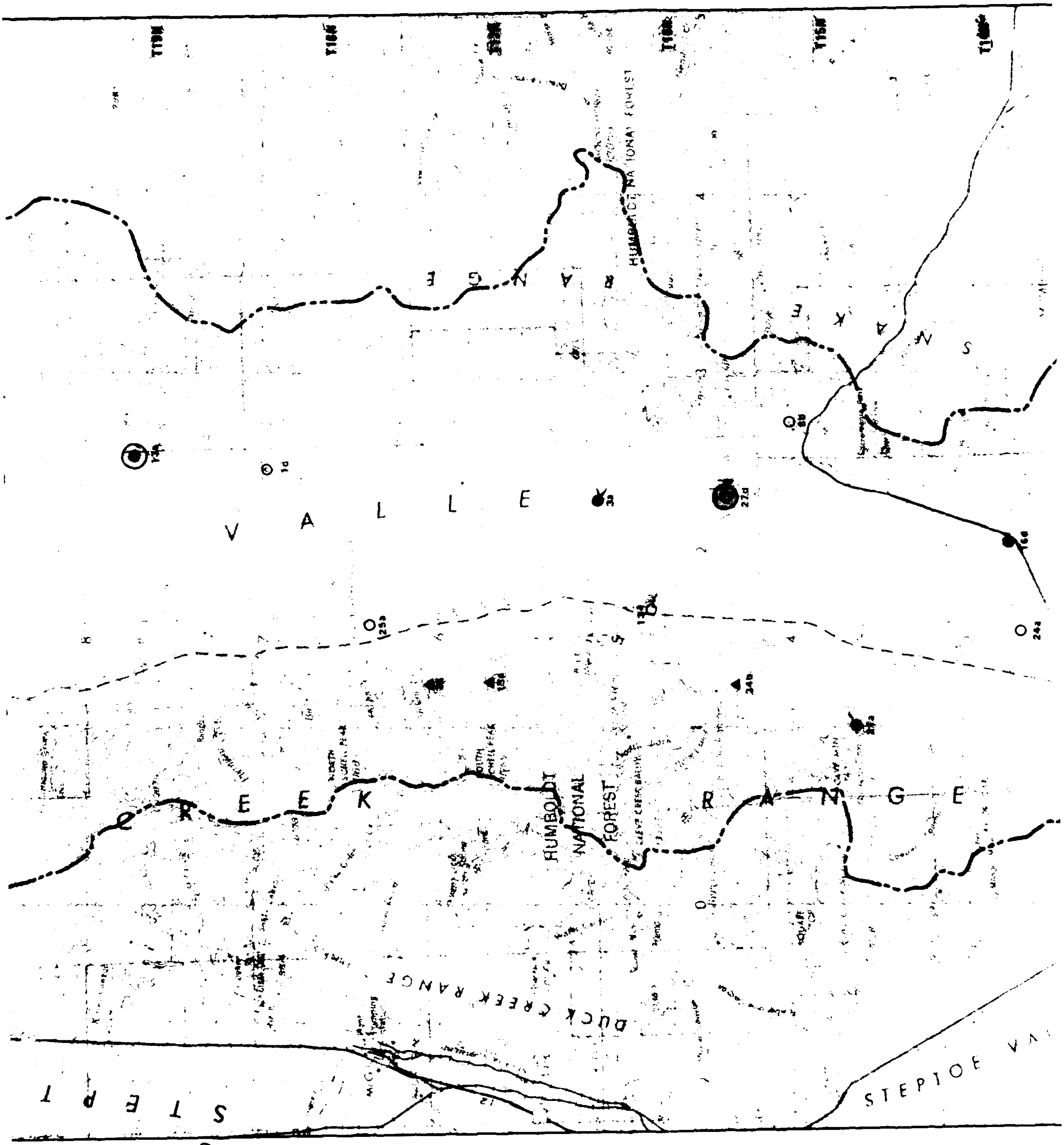
2



NOTES

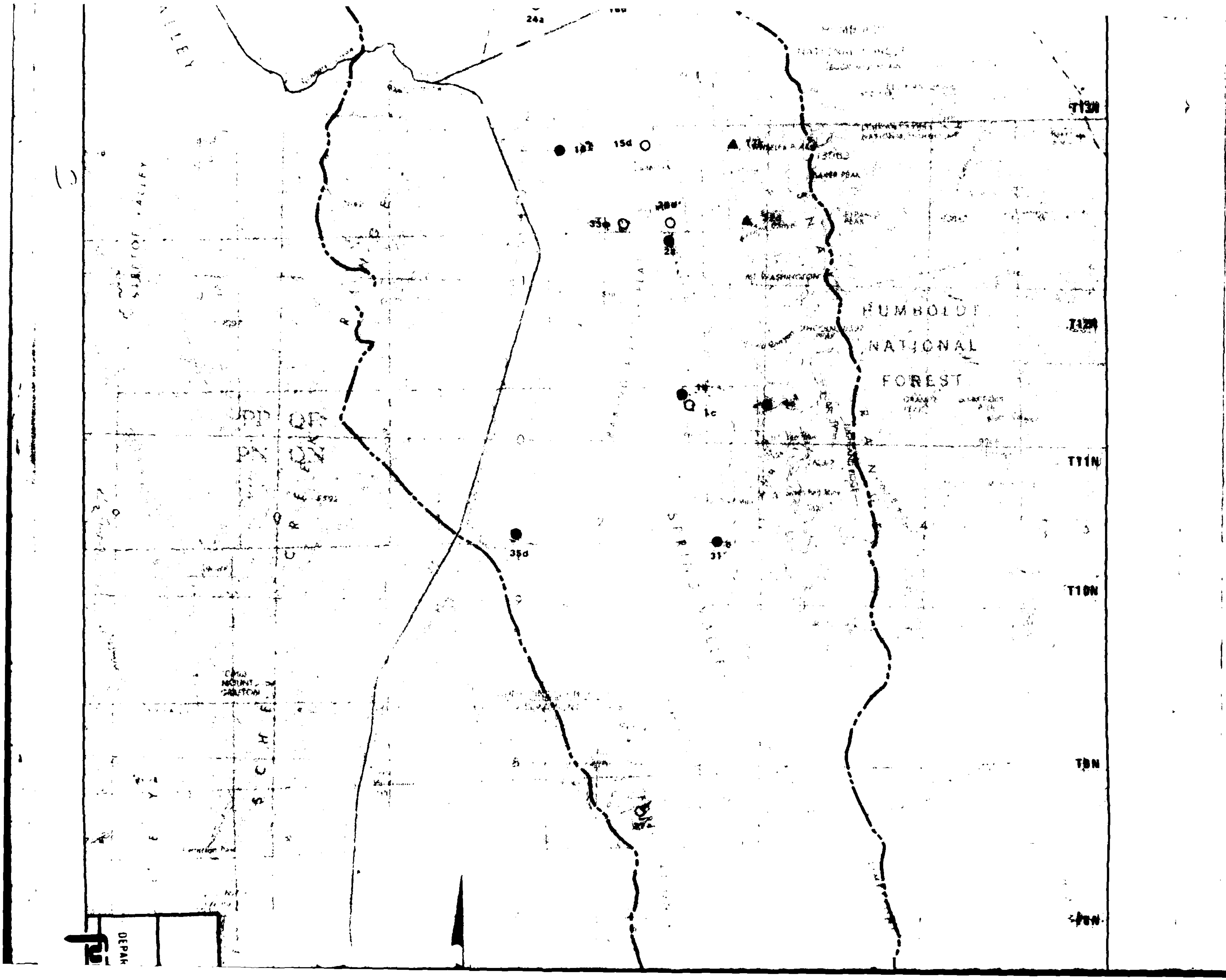
(1) POTABLE WATER QUALITY CRITERIA ARE LISTED IN TABLE C1-1

(2) OF THE 361 SAMPLES ANALYZED FOR WATER QUALITY TO DATE, 67 PERCENT MET THE STANDARDS FOR GOOD QUALITY AS LISTED IN TABLE C1-1. THEREFORE, IN AREAS WHERE THERE ARE NO DATA, WATER IS ASSUMED TO BE OF GOOD QUALITY. IN AREAS WHERE THE LIMITS OF WATER QUALITY DEGRADATION COULD NOT BE PROJECTED, A 1 MILE DIAMETER CIRCLE WAS DELINEATED AROUND THE SAMPLING POINT.

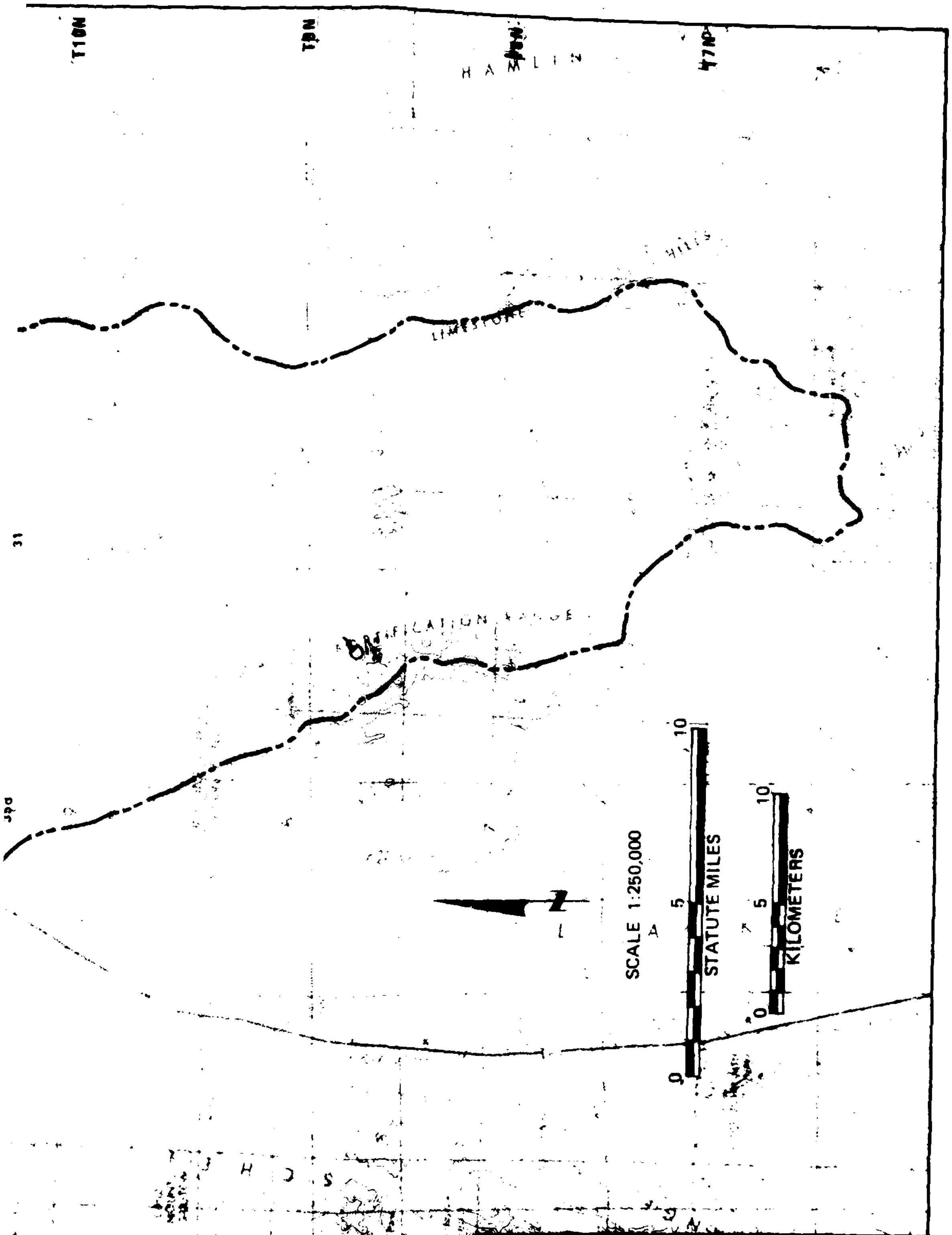


HUMBOLDT NATIONAL FOREST
R A N G E
S N A K E
V A L L E
C R E E K R A N G E
HUMBOLDT NATIONAL FOREST
DUCK CREEK RANGE
STEPTOE VA
S T E P T

2



HUMBOLDT
NATIONAL
FOREST
T13N
T12N
T11N
T10N
T9N
15d
28
1c
31
35d
24a
MT. WASHINGTON
MOUNT CARLTON
DEPAR



WATER QUALITY
SPRING VALLEY, NEVADA

MX SITING INVESTIGATION DEPARTMENT OF THE AIR FORCE - BMO	FIGURE D1-8

FUGRO NATIONAL, INC.

4

APPENDIX E1.0

SUMMARY OF AQUIFER TEST DATA
NEVADA-UTAH

WELL LOCATION	DURATION OF TEST (hours)	DIAMETER OF WELL (inches)	SCREENED LENGTH (feet)	PUMPING RATE (gpm)	MAXIMUM DRAWDOWN (feet)	TRANSMISSIVITY (ft^2/day)
SPRING VALLEY						
12N/67E-13dd	75	16	104	537	85.2	474[1]

Transmissivity value based on:

1 recovery data.

NOTE: UTAH LOCATIONS BASED ON SALT LAKE BASELINE AND MERIDIAN. NEVADA LOCATIONS BASED ON MT. DIABLO BASELINE AND MERIDIAN.

SUMMARY OF AQUIFER TEST DATA
NEVADA–UTAH

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE — BMO

TABLE E1-1

FUGRO NATIONAL, INC.

APPENDIX F1.0

DISCHARGE MEASUREMENTS

APPENDIX F

TABLE OF CONTENTS

LOCATION	SOURCE	DATE OF MEASUREMENT-MO.-YR.	ELEVATION (Feet)	DISCHARGE (gpm)
11N/55E-17	Portuguese Sp.	5-80	6880	2-3E
10N/52E-23aa	Squaw Wells Sp.	5-80	6960	3
10N/54E-25	Martin Sp.	5-80	7320	2-3E
9N/52E-12baa	Needles Sp.	5-80	6580	2-3E

E - DISCHARGE ESTIMATED

NOTE: MEASURED BY FUGRO NATIONAL EXCEPT WHERE NOTED.
NEVADA LOCATIONS BASED ON MT. DIABLO BASELINE AND MERIDIAN.
UTAH LOCATIONS BASED ON SALT LAKE BASELINE AND MERIDIAN.
WHERE PUBLISHED DATA ARE LACKING OR INACCURATE GROUND SURFACE ELEVATIONS ARE TAKEN FROM TOPOGRAPHIC MAPS.

DISCHARGE MEASUREMENTS
BIG SAND SPRINGS VALLEY, NEVADA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - BMO

TABLE F1-1

FUGRO NATIONAL, INC.

LOCATION	SOURCE	DATE OF MEASUREMENT-MO.-YR.	ELEVATION (Feet)	DISCHARGE (gpm)
1N/61E-29ca	Oreana Spring	6-80	6000	3-4E

E - DISCHARGE ESTIMATED

NOTE MEASURED BY FUGRO NATIONAL EXCEPT WHERE NOTED.
NEVADA LOCATIONS BASED ON MT. DIABLO BASELINE AND MERIDIAN.
UTAH LOCATIONS BASED ON SALT LAKE BASELINE AND MERIDIAN.
WHERE PUBLISHED DATA ARE LACKING OR INACCURATE GROUND SURFACE ELEVATIONS ARE TAKEN FROM TOPOGRAPHIC MAPS.

DISCHARGE MEASUREMENTS
COAL VALLEY, NEVADA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - BMO

TABLE F1-2

FUGRO NATIONAL, INC.

LOCATION	SOURCE	DATE OF MEASUREMENT-MO.-YR.	ELEVATION (Feet)	DISCHARGE (gpm)
3N/56E-23a	Pine Creek	6-80	6900	750
3N/56E-32a	Cottonwood Ck.	6-80	7000	988
3N/56E-33c	Cottonwood Ck.	6-80	6800	850
3N/57E-16c	Cherry Creek	6-80	6200	1000E
3N/57E-16d	spring	6-80	6150	3
2N/56E-23b	Barton Spring	6-80	6400	<1
2N/59E-17a	stream	6-80	5100	40E
do	do	6-80	5100	<1E
1N/57E-20	spring	6-80	6500	12

E - DISCHARGE ESTIMATED

NOTE: MEASURED BY FUGRO NATIONAL EXCEPT WHERE NOTED.
NEVADA LOCATIONS BASED ON MT. DIABLO BASELINE AND MERIDIAN.
UTAH LOCATIONS BASED ON SALT LAKE BASELINE AND MERIDIAN.
WHERE PUBLISHED DATA ARE LACKING OR INACCURATE GROUND SURFACE ELEVATIONS ARE TAKEN FROM TOPOGRAPHIC MAPS.

DISCHARGE MEASUREMENTS
GARDEN VALLEY, NEVADA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - BMO

TABLE
F1-3

FUGRO NATIONAL, INC.

LOCATION	SOURCE	DATE OF MEASUREMENT-MO.-YR.	ELEVATION (Feet)	DISCHARGE (gpm)
10N/65E-19d1	N. Creek Sp.	8-63	7800	770[2]
10N/65E-29c1	Ltl. N. Ck. Sp.	8-63	7800	40[2]
9N/65E-4c1	Geyser Spring	8-63	7120	6[2]
9N/65E-13ba	well	6-50	5950	12[1]
9N/65E-13bd	well	6-50	5950	65[1]
9N/65E-13cc	well	6-67	5940	100[1]
9N/65E-30d	Patterson Sp.	8-63	7800	10[2]
6N/65E-23b	Burnt Corl. Sp.	8-63	6720	1[2]
6N/68E-11c1	Cole Rch. Sp.	8-63	8120	25[2]
5N/66E-6d	Poney Spring	8-63	6162	10[2]
5N/68E-17a1	Cottino Sp.	8-63	7000	100E[2]

References:

1. Nevada State Engineers Office, 1979.
2. Rush and Eakin, 1963.

E - DISCHARGE ESTIMATED

NOTE: MEASURED BY FUGRO NATIONAL EXCEPT WHERE NOTED.
NEVADA LOCATIONS BASED ON MT. DIABLO BASELINE AND MERIDIAN.
UTAH LOCATIONS BASED ON SALT LAKE BASELINE AND MERIDIAN.
WHERE PUBLISHED DATA ARE LACKING OR INACCURATE GROUND SURFACE ELEVATIONS ARE TAKEN FROM TOPOGRAPHIC MAPS.

DISCHARGE MEASUREMENTS
LAKE VALLEY, NEVADA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - BMO

TABLE
F1-4

FUGRO NATIONAL, INC.

LOCATION	SOURCE	DATE OF MEASUREMENT-MO.-YR.	ELEVATION (Feet)	DISCHARGE (gpm)
7N/64E-25dcc	spring	5-80	6320	<1E
5N/64E-7ddd	Big Mud Spring	5-80	6380	6
5N/65E-10cab	Horse Corl. Sp.	5-80	6360	7.5
5N/65E-15aba	North Mud Sp.	5-80	6400	2E
5N/65E-21abb	spring	5-80	6300	2-3E
5N/65E-32ad	Malloy Spring	5-80	6140	82
4N/65E-4dbd	Little Fld. Sp.	5-80	6150	10E
4N/65E-29cb	Bailey Spring	5-80	6044	2-3E

E - DISCHARGE ESTIMATED

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DISCHARGE MEASUREMENTS
MULESHOE VALLEY, NEVADA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - BMO

TABLE
F1-5

FUGRO NATIONAL, INC.

LOCATION	SOURCE	DATE OF MEASUREMENT-MO.-YR.	ELEVATION (Feet)	DISCHARGE (gpm)
5S/61E-24dcc	Sixmile Spring	5-80	5320	dry

E - DISCHARGE ESTIMATED

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DISCHARGE MEASUREMENTS
PAHROC VALLEY, NEVADA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - BMO

TABLE
F1-6

FUGRO NATIONAL, INC.

LOCATION	SOURCE	DATE OF MEASUREMENT-MO.-YR.	ELEVATION (Feet)	DISCHARGE (gpm)
2N/55E-19cdd	Quinn Can. Sp.	6-80	6800	55
1N/56E-9daa	McCutchen Sp.	6-80	5800	1.2
1S/56E-12adb	Wild Horse Sp.	6-80	6200	12
2S/54E-16cac	spring	6-80	6100	0.5E
2S/55E-26dda	Sand Spring	10-71	4805	0.2[1]
do	do	6-80	4805	no flow
2S/57E-16bb	spring	6-80	5900	no flow
2S/57E-22acc	spring	6-80	6300	3
2S/57E-22dab	spring	6-80	6300	dry
2S/57E-28ddb	The Seeps	6-80	6000	4E

References:

1. Van Denburgh and Rush, 1974.

E - DISCHARGE ESTIMATED

NOTE: MEASURED BY FUGRO NATIONAL EXCEPT WHERE NOTED.
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DISCHARGE MEASUREMENTS PENOYER VALLEY, NEVADA	
MX SITING INVESTIGATION DEPARTMENT OF THE AIR FORCE - BMO	TABLE F1-7

FUGRO NATIONAL, INC.

LOCATION	SOURCE	DATE OF MEASUREMENT-MO.-YR.	ELEVATION (Feet)	DISCHARGE (gpm)
23N/66E-31a1	Henroid Well	7-64	6380	50[2]
23N/66E-31b2	Henroid Well	8-49	6370	5[2]
23N/67E-14ba	Tippet Spring	-	6000	150E[1]
22N/66E	Seigel Creek	7-64	—	890[2]
21N/65E	North Creek	7-64	—	1000[2]
20N/66E-7	Muncy Creek	7-64	7000	1898[2]
20N/66E-30c	Kalamazoo Cr.	6-80	6800	1849
18N/66E-10	Bassett Creek	1-80	6200	1350[3]
17N/66E-3ab	McCoy Creek	6-80	7000	8527
17N/66E-15ac	Taft Creek	6-80	7200	5794
17N/67E-25ca	So. Mulick Sp.	-	5600	200E[1]
16N/66E-34ba	Cleave Creek	6-80	6240	11983[3]
15N/66E-21ac	Bastain Spring	6-80	6640	1650E
15N/67E26cd	well	6-80	5700	<1
14N/67E-7d1	Experimental Fm.	11-44	5800	182[2]
13N/67E-34a1	well	-	5780	5[2]

References:

1. Mifflin, 1968.
2. Rush and Kazmi, 1965.
3. U.S. Geological Survey, 1980, Oral Communication.

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DISCHARGE MEASUREMENTS
SPRING VALLEY, NEVADA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - BMO

TABLE F1-8
1 OF 3

FUGRO NATIONAL, INC.

LOCATION	SOURCE	DATE OF MEASUREMENT-MO.-YR.	ELEVATION (Feet)	DISCHARGE (gpm)
13N/67E-35c1	BLM Well	8-49	5800	50[2]
13N/67E-35d1	BLM Well	8-49	5830	5[2]
13N/68E-17cb	Pine Creek	6-80	6880	2580
13N/68E-32bd	Williams Cr.	6-80	7520	4580E
12N/67E-2a	well	6-80	5800	36
12N/67E-2a1	BLM Well	7-64	5800	50[2]
12N/67E-2a2	Fi. & Gm. Well	3-50	5800	1[2]
12N/67E-2a3	BLM Well	3-50	5800	<1[2]
12N/67E-2a4	BLM Well	3-50	5800	45[2]
12N/67E-2a5	Fi. & Gm. Well	3-50	5800	40[2]
12N/67E-13b1	Kirkeby Well	7-49	5800	5[2]
12N/67E-24b1	Kirkeby Well	7-59	5840	7[2]
11N/67E-1bc	well	6-80	5790	6
11N/67E-1c1	Shallow Well	3-50	5820	36[2]
11N/66E-1ab	well	6-80	5770	<1
11N/66E-35db	well	6-80	5784	2.5

References:

1. Mifflin, 1968.
2. Rush and Kazmi, 1965.
3. U.S. Geological Survey, 1980, Oral Communication.

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DISCHARGE MEASUREMENTS
SPRING VALLEY, NEVADA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - BMO

TABLE F1-8
2 OF 3

FUGRO NATIONAL, INC.

LOCATION	SOURCE	DATE OF MEASUREMENT-MO.-YR.	ELEVATION (Feet)	DISCHARGE (gpm)
11N/67E-1a	Shoeshone Sp.	4-60	5780	2[2]
11N/67E-1bc	Shoeshone Sp.	6-80	5775	6
11N/67E-1cd	Shoeshone Sp.	-	5800	300E[1]
11N/67E-12da	Minena Sp.	-	6160	300E[1]
11N/68E-4c	Wallow Sp.	6-80	6400	42,000E
11N/68E-5ca	spring	6-80	6080	359

References:

1. Mifflin, 1968.
2. Rush and Kazmi, 1965.
3. U.S. Geological Survey, 1980, Oral Communication.

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DISCHARGE MEASUREMENTS
SPRING VALLEY, NEVADA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - BMO

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FUGRO NATIONAL, INC.

APPENDIX G1.0

PROGRAM STATUS AND METHODS OF INVESTIGATION

APPENDIX G

TABLE OF CONTENTS

APPENDIX G1.0
PROGRAM STATUS AND METHODS OF INVESTIGATION

G1.1 Valley Reconnaissance Program

Field hydrogeologic reconnaissance studies have been completed in 29 valleys as of the end of FY 80. Results and conclusions for the first 16 valleys studied were included in the "Summary for Draft Environmental Impact Statement" (FN-TR-38D). Results for an additional eight valleys are included in Section 3.0 of this report. Field reconnaissance studies for these valleys included the same tasks and methods of investigation described in previous reports. Hydrogeologic interpretations for the remaining five valleys studied during FY 80 are in progress and will be presented in FY 81.

G1.2 Drilling and Testing Programs

G1.2.1 Valley-fill Aquifer

The objectives of the valley-fill aquifer drilling and testing program are to determine aquifer and water-quality characteristics where little data exist and to provide information in support of water appropriation applications through monitoring of springs and existing wells during test pumping. Wells drilled during this program have been divided into two nominal drilling depths.

Shallow well (about 500 feet [152 m]) drilling and testing sites were selected in those valleys in which valley-fill water levels were believed to be less than 350 feet (107 m) and where existing data on aquifer characteristics were sparse. The sites were located in proximity to springs or existing wells in order to measure the possible effects of test-well pumping.

The site-selection process for intermediate depth wells (about 1000 feet [305 m]) involved consideration of four criteria: 1) valleys having existing high rates of withdrawals of ground water from shallow aquifers indicating possible keen competition for water and the need to identify alternative sources; 2) the lack of comprehensive data; 3) hydrogeologically favorable areas within a valley; and 4) specific sites with acceptable access and other conditions favorable to efficient drilling operation.

Within each valley, favorable hydrogeological areas were considered where a stratigraphic layering of fine-grained deposits (confining) and coarse-grained deposits (aquifer) were expected. These areas were generally near the base of the alluvial fans extending outward into the valley from the mountain fronts. Here, fine-grained playa deposits were expected to interfinger with the coarser-grained fanglomerates. These potential siting areas were refined to include only those areas having little or no existing nearby hydrogeologic data.

The testing consisted of a step-drawdown test of eight to 12 hours duration to determine well capacity, followed by a constant discharge test for seven to 30 days, followed by a one- to two-day recovery test to determine aquifer characteristics and the effects of ground-water withdrawal on local spring discharge and the water level in existing wells.

Prior to, during, and after testing, all spring discharges and water levels in wells near the test wells are measured to assess any potential impact incurred during aquifer testing operations.

Water sampling for quality analyses is conducted as part of each drilling and testing program. The water quality analyses include determination of heavy metal concentrations in addition to those ions analyzed as part of shallow aquifer reconnaissance studies.

During FY 80, 10 shallow-depth and eight intermediate-depth well sets were drilled as part of this program. Aquifer testing has been completed or is currently in progress for 12 well sets. However, testing data have only been analyzed for those wells which were presented in FN-TR-38D. Aquifer testing of the remaining well sets drilled during FY 80 will be started as soon as present tests are completed. The results of the aquifer tests for these wells will be presented in a progress report which will be submitted in January 1981.

G1.2.2 Carbonate Rock Aquifer

The objectives of the Carbonate Aquifer exploratory drilling program are to determine the source, occurrence, and movement of ground water and the hydraulic charateristics of the regional carbonate aquifer flow system in the White River drainage area. Four carbonate wells are scheduled to be drilled by the end of FY 80 (30 September); at least two of the wells will be pump-tested and the others will remain as piezometer wells for ground-water level monitoring.

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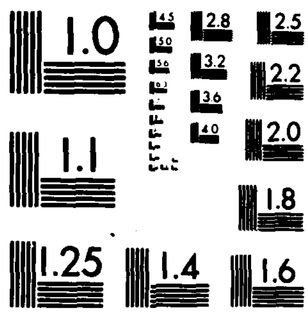

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

The carbonate wells will range in depth from 500 to 2500 feet (152 to 762 m) and will be drilled by rotary and air-hammer methods. For those wells that will be pump-tested, the borings will be 12 1/4-inches (31.1 cm) in diameter to about 50 feet (15 m) into solid bedrock and cased with 10-inch (25.4-cm) ID casing. The casing will keep unconsolidated material from dropping into the well during subsequent drilling and will provide a ground seal that will be accessible for later water-level monitoring and water-quality sampling. The remainder of the well will be drilled with a 9 3/4-inch (24.8-cm) bit and cased with 8-inch (20.3-cm) ID casing.

Pump tests will be conducted for up to 30 days in each well at the highest rate practical for the conditions. The monitoring of spring discharge and well-water levels in the vicinity of the test well will be conducted as discussed for the other drilling/testing programs.

Isolation water sampling (using packers) for quality analysis will be conducted to evaluate the quality of water from different aquifers penetrated. Also, downhole ground-water flow measurements will be made where possible.

Four wells will be drilled and tested for this program under FY 80 funding. At the present time, two wells are nearly completed, one in Steptoe Valley and one in Coal Valley. Aquifer testing of these wells will be conducted immediately after the drilling is completed. Two additional wells will be drilled as part of the FY 80 program. These wells will be at two of three potential sites: Cave Valley, Dry Lake Valley, and the Coyote/Kane Springs Operational Base sites. Results of this work will be presented in a progress report which will be submitted in January 1981.

G1.3 Surface-Water Hydrology Study

The Surface-Water Hydrology study has been completed for 35 valleys in the Nevada-Utah siting area.

The study was conducted to improve the understanding of surface water characteristics and the recharge potential in the siting area. The results of the study will be input to the ground-water computer models of valleys to enhance the accuracy of the models pursuant to evaluating the effects of MX ground-water withdrawals on the local water users and the environment. Results for the eight valleys listed in Section 3.0 have been incorporated into the valley sections.

The study included the tasks listed below.

- Identify surface-water regimes in each valley of deployment area;
- Assemble available state and U.S. Geological Survey surface-water and water-quality data records;
- Develop hydrographs for a variety of mountain and foothill streams;
- Statistically assess runoff versus precipitation as a function of drainage basin characteristics, including elevation;
- Assess stream losses from mountain fronts as a means of evaluating recharge;
- Assess seasonal runoff characteristics;
- Prepare water budget for different drainage areas;

- o Assess flooding potential below rock areas;
- o Assess the relationship between ground water and surface water in each valley; and
- o Prepare a summary report for each valley and a report for the general siting area.

G1.4 Basin Structural Analysis

The basin structural analysis was initiated in the fall of 1979 (FY 80) to evaluate deep-basin structures and to identify potential water-bearing carbonate rock units and the confining units which may separate them. This study provides support information for the carbonate aquifer drilling and testing program and for the computer modeling efforts. It also helps to identify possible water supply alternatives for the MX project in certain areas. The study was largely completed in January 1980 although it will be updated as new information and data become available. The study has included collection and compilation of available published literature including maps, structural cross sections, and oil and water well data in [illegible] to construct cross sections of the siting area.

G1.5 Numerical Modeling

Computer numerical models have been used on selected valleys to synthesize the ground-water regime. The models, when calibrated and verified, are useful in assessing impacts of proposed pumping and as management tools when water withdrawals for construction begin. The model chosen for this task is the two-dimensional Trescott, Pinder, Larson finite-difference model as published by the U.S. Geological Survey (Trescott, Pinder, and Larson, 1976). This model was chosen because of its ready availability, its proven reliability and acceptance by the hydrological community, and the availability of the documentation and assistance from the U. S. Geological Survey. Nine valleys have been selected for modeling during FY 80. The choice of valleys was based on the availability of data on aquifer properties and water budgets and on whether water is in short supply or where the competition for water is keen. Of the nine valleys selected for modeling, seven have been completed. The models are for Snake, Hamlin, White River, Dry Lake, Pine, Wah Wah, and Muleshoe valleys. Modeling of Railroad and Delamar valleys is in progress.

Snake, Hamlin, White River, and Railroad valleys were selected because of the relatively good data base available and because of the extensive development of ground-water resources for agriculture. Dry Lake, Delamar, and Muleshoe valleys were chosen because of the possible short supply of water; wells were drilled and tested in Dry Lake and Delamar valleys. Pine, Wah Wah, and Tule valleys were selected because the available data, although sparse, are better than that from some of the other valleys in the study area. Tule Valley is also being studied in the valley-fill aquifer drilling and testing program which will provide additional supportive data.

G1.6 Municipal Water-Supply and Wastewater-Treatment Study

Studies of the existing municipal water demand, potential supply, and impact of future growth on both water supply and sewage transmission and treatment facilities were initiated for the Nevada-Utah siting area late in calendar year 1979. The studies were conducted for Fugro National, Inc. by the Desert Research Institute for towns within or near the MX siting area in Nevada and by the Utah Water Research Laboratory for towns within or near the siting area in Utah. These studies were conducted to define the potential effects of MX-related population growth on existing water-supply and wastewater-treatment facilities and included the following:

- An assessment of the existing municipal water resources and the impacts of increased water use on Tonopah, Ely, Caliente, and Pioche, Nevada, and Delta, Milford, and Cedar City, Utah, including the identification of each municipality's source of water, the quantity present, and the amount of present usage;
- Identification of the maximum capacity and the ability of the water supply and sewage systems to accommodate increased usage, without modification of the systems;
- Evaluation of the water-quality limitations of the water supply systems;
- Recommendation of the necessary water-supply and wastewater-treatment facility improvements required for increased usage and the economics of an increase if modification is required; and
- An overview of the effects of increased water usage in small towns without municipal water and sewer systems. These towns include such as Baker, Lund, Preston, Alamo, Panaca, Garrison, and others that lie within or at the margins of the Nevada-Utah siting area.

The studies, which were completed by early summer 1980, were based upon recent water-system planning reports by private consultants and state and federal agencies supplemented by communication with community officials. Available information on the design criteria and population projections were also utilized.

G1.7 Water Rights Legal Studies

Phase I and Phase II of the water rights and water law study conducted by the DRI for Fugro National, Inc. were completed in the spring and early summer of 1980, respectively. The method of investigation along with the results and conclusions for Phase I of the study were presented in the "Geotechnical Summary, Water Resources Program, FY 79." A summary of the results and conclusions for Phase II of this study are presented in Section 4.0 of this report.

G1.8 Industry Activity Inventory

An industry activity inventory covering the area within and near the potential Nevada-Utah siting area was initiated late in calendar year 1979. The work was conducted for Fugro National, Inc. by the Desert Research Institute for the Nevada siting area and by the Utah Water Research Laboratory for the Utah siting area. The results of these inventories are summarized in Section 5.0. The inventories were conducted because large-scale industrial, commercial, or mining projects in the siting area could create competition for water with the proposed water withdrawals for MX. Together, these studies provide a basis for joint consideration of how best to meet the water-supply needs for the MX missile system in the most optimal way with consideration of other future users. To accomplish this task the studies included the following:

- o Inventory of existing and proposed major industrial, mining, grazing, energy-extraction, energy-transporting, and energy-producing activities.

- o General assessment of present and future water requirements for enterprises in the region including estimates of location and timing of need with respect to most likely sources of supply. The inventory included, but was not limited to, the following: coal mining operations, nuclear power plants, solar power projects, geothermal explorations, thermal electric generation, coal slurry transport, and mining, grazing, agricultural, and recreation requirements. The water-quality dimension of the problem was also addressed.

- o Identify the potential water-transfer possibilities amongst the industries and other water-use interactions within the region (with reference to conflicts such as land use and environmental aspects).

The studies included only pertinent projects beyond their preliminary planning stage. All available information from Fugro National, respective state and federal agencies, and individual private companies was utilized. The studies were completed in the summer of 1980.

G1.9 <u>Water Appropriations</u>

The program to apply for appropriation of ground water to supply MX requirements was completed for 29 valleys at the end of FY 80. Land surveys of the anticipated locations of ground-water withdrawal in six additional valleys will be initiated shortly. This program consists of the following tasks:

- o Finalize the quantity of ground-water required in each valley;
- o Locate wells for source for MX construction water in each valley;
- o Meet with state engineers in Utah and Nevada;
- o Establish valley priorities;
- o Institute field water-diversion surveys; and
- o Survey of water rights which might be leased or purchased.

APPENDIX H1.0

GLOSSARY OF SELECTED
HYDROGEOLOGIC TERMINOLOGY

GLOSSARY OF SELECTED HYDROGEOLOGIC TERMINOLOGY

AQUIFER - A body of rock that contains sufficient saturated, permeable material to yield significant quantities of ground water to wells and springs.

- Confined Aquifer - An aquifer bounded above and below by impermeable bed(s) of distinctly lower permeability than that of the aquifer itself.
- Deep Aquifer - A consolidated rock aquifer, or carbonate aquifer when contained in limestone or dolomite rock, which occurs beneath the unconsolidated valley-fill sediments and in the mountain ranges. This aquifer is the conduit for any interbasin or regional-flow systems which exist. Flow is believed to be primarily through fracture and solution openings rather than intergranular.
- Perched Aquifer - An aquifer separated from an underlying main body of ground water by an unsaturated zone.
- Intermediate Aquifer - An intermediate aquifer is arbitrarily defined as an aquifer that occurs below 500 feet in the unconsolidated valley-fill sediments.
- Shallow Aquifer - A shallow aquifer is arbitrarily defined as an aquifer that occurs in the upper 500 feet of unconsolidated valley-fill sediments.
- Unconfined Aquifer - (Water-table aquifer) An aquifer that has a free water table which is not confined under pressure beneath relatively impermeable stratum.

ARTESIAN - An adjective referring to ground water confined under hydrostatic pressure.

DRAWDOWN - The distance by which the level of an reservoir is lowered by the withdrawal of water.

EVAPOTRANSPIRATION - The process by which ground water becomes atmospheric water either by evaporation from a surface or transpiration by plants. No effort is made to distinguish between the two.

HYDRAULIC CONDUCTIVITY - The amount of water flowing through a unit area of aquifer normal to a unit gradient. It is a measure of the ease with which a material transmits water.

HYDROSTATIC PRESSURE - The pressure exerted by the water at any given point in a body of water at rest. The hydrostatic pressure of ground water is generally due to the weight of water at higher levels in the zone of saturation.

LACUSTRINE - Pertaining to, produced by, or formed in a lake or lakes.

PERENNIAL YIELD - The amount of water that can be withdrawn on a continuous basis without causing an undesirable result.

The term "undesirable result" is not defined, but may include intrusion of water of undesirable quality, reduction of head below an economic pumping level, or environmental effects such as destruction of marshy wildlife habitat or destruction of useful phreatophytes. Perennial yield must be less than the long-term average recharge, but other than that, generalizations cannot be made. Perennial yield cannot be computed until a management decision has been made on the definition of an undesirable result. Perennial yield in this report refers to state and federal estimates. These estimates are not accompanied by a quantification or definition of undesirable effects.

PHREATOPHYTE - A plant which takes water directly from the capillary fringe or water table. In the MX siting area, these are primarily greasewood, rabbitbrush, saltgrass, and pickleweed.

POORLY SORTED - Consisting of particles of many sizes mixed together in an unsystematic manner.

POTENTIOMETRIC SURFACE - An imaginary surface representing the total head of water in an aquifer. It is the level at which water will stand in a properly constructed well. Ground water always flows from higher to lower potential and perpendicular to contours on the potentiometric surface.

SPECIFIC CAPACITY - The rate of discharge of a water well per unit of drawdown, commonly expressed in gallons per minute per foot.

SPECIFIC YIELD - The volume of water which will drain from a saturated unit volume of an unconfined aquifer under the influence of gravity. Expressed as a ratio or percentage.

STORAGE COEFFICIENT - The amount of water added to or removed from storage per unit of surface area of a confined aquifer per unit of change in head normal to that surface. Expressed as a decimal ratio.

TRANSMISSIVITY - The amount of water flowing through a unit width of an aquifer in response to a unit gradient. It is a measure of the ability of an aquifer to transmit water. It is numerically equal to the conductivity times the aquifer thickness.

WELL-SORTED - Consisting of particles all having approximately the same size.

APPENDIX I1.0

REFERENCES CITED

REFERENCES CITED

Carpenter, Everett, 1915, Ground water in southeastern Nevada: U.S. Geological Survey Water-Supply Paper 365, 86 p.

Cochran, G. F., Clark, D. L., Moser, R. D., Bird, I.W., and Federici, J. M., 1980, Water rights in Nevada and Utah: an inventory within the MX area, Desert Research Institute, University of Nevada System, 227 p.

Dinwiddie, G. A. and Schroder, L. G., 1971, Summary of hydraulic testing in and chemical analyses of water samples from deep exploratory holes in Little Fish Lake, Monitor, Hot Creek, and Little Smoky valleys, Nevada: U.S. Geological Survey, Report No. USGS-474-90, 70p.

Eakin, Thomas E., 1963, Ground-water appraisal of Cave Valley in Lincoln and White Pine counties, Nevada; Nevada Department of Conservation and Natural Resources, Ground Water Resources Reconnaissance Series Report 13, 19 p.

Eakin, T. E., Moore, D. O., and Everett, D. E., 1965, Water-resources appraisal of the upper Reese River Valley, Lander and Nye counties, Nevada: Nevada Department Conservation and Natural Resources, Water Resources Reconnaissance Series Report 31, 47 p.

Eakin, Thomas E., Price, Don, and Harrill, J. R., 1976, Summary appraisals of the nation's ground-water resources-Great Basin Region: U.S. Geological Survey Professional Paper 813-G, 37 p.

Henningson, Durham, and Richardson, 1980, Water Resources, M-X ETR-12: Santa Barbara, California. Unpublished report.

Howard, Eugene L., 1978, Geologic map of eastern Great Basin: Terra Scan Group Ltd., scale 1:250,000.

Mifflin, Martin D., 1968, Delineation of ground-water flow systems in Nevada; Nevada University, Desert Research Institute, Technical Report Series H-W, Hydrology and Water Resources Publication No. 4, 111 p.

Nevada, State of, 1971, Map: Water resources and inter-basin flows, Division of Water Resources, State Engineer's Office, scale 1:750,000.

Oral Communication, Soil Conservation Service, 1980, Mr. Melvin Cheney.

Rush, Eugene and Everett, Duane, 1966, Water-resources appraisal of Little Fish, Hot Creek, and Little Smoky valleys, Nevada: Nevada Department of Conservation and Natural Resources, Water Resources Reconnaissance, Report No. 38, 39p.

REFERENCES CITED

Rush, F. E., 1964, Ground-water appraisal of the Meadow Valley area, Lincoln and Clark counties, Nevada: Nevada Department of Conservation and Natural Resources, Water Resources Reconnaissance Series Report 27, 43 p.

Rush, F. E. and Eakin, T. E., 1963, Ground-water appraisal of Lake Valley in Lincoln and White Pine counties, Nevada: Nevada Department of Conservation and Natural Resources, Water Resources Reconnaissance Series Report 24.

Rush, F. E. and Kazmi, S. A. T., 1965, Resources appraisal of Spring Valley, White Pine and Lincoln County, Nevada: Nevada Department of Conservation and Natural Resources, Water Resources Reconnaissance Series Report No. 33.

Trescott, P. C., Pinder, G. F. and Larson, S. P., 1976, finite difference model for aquifer simulation in two dimensions with results of numerical experiments: Technical of Water-Resources Inventory of U.S. Geological Survey Book 7, Chp. cl, 116p.

Van Denburgh, A. and Rush, F. Eugene, 1974, Water-resources appraisal of Railroad and Penoyer valleys, east-central Nevada: Nevada Department of Conservation and Natural Resources, Water Resources Reconnaissance Series. Report 60, 61 p.

Worts, G.F., 1967 "The Available Water Supply" in Rush, R. E., and Glancy, P. A. Water-resources Appraisal of the Warm Springs. Lemmon Valley Area, Washoe County, Nevada: Nevada Department Conservation and Natural Resources, Water Resources Reconnaissance Series Report 43, p. 48-53.

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